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ABSTRACT

Designed to provide educational policy-makers and decision-makers with a basis for the development of guidelines for the development of education programs, this report presents an overview of trends and issues in computer education within the countries of the Asia and Pacific region. The impact of computers on society is described, as well as the more recent impact of the microcomputer on classrooms in the region. Likely future developments in computing are then discussed, together with the need for research on the effectiveness of computer instruction and how best to introduce computer use in education. Policy issues considered include the relationship of schools to society; equity of access to information; security and privacy; ergonomic and health factors; and computer awareness in the broader community. Hardware considerations are also discussed, including evaluation and selection; costs; site preparation; maintenance; local requirements; special features; and insurance. Various instructional and management applications of computers and the need for the development of appropriate software are considered, as well as the need for both preservice and inservice education for teachers. Curriculum requirements at the school level, postsecondary or tertiary level, and for nonformal education are also examined. Discussion of key issues to be considered in developing a national policy on computer education and an examination of new demands being made on literacy teaching conclude the report. Twenty-five references and a glossary of computer terms are appended. (KM)

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Asia and the Pacific Programme of
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Asia and the Pacific Programme of
Educational Innovation for Development

DEVELOPING COMPUTER USE IN EDUCATION

Guidelines, trends and issues

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Unesco Regional Office
for Education in Asia and the Pacific
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PREFACE

Following the recommendations of the 8th Regional Consultation Meeting on the Asia and the Pacific Programme of Educational Innovation for Development (APEID), held in March 1983, relating to Information, Communication Support and Functioning of the APEID network, an Experts Planning Meeting on the Use of Computers in Education was held in Bangkok from 2 - 7 December 1985 addressing itself to the following objectives:

1. Review current experiences and trends in the use of computers in education;
2. Analyse likely future developments in the use of computers at all levels of education; and
3. Prepare suggestions for regional activities, and guidelines for the introduction/expansion of computer use in education and the development of computer literacy.

This Meeting was built on the outcomes of the Third Asian Seminar on Educational Technology, organized by the Japan Council of Educational Technology Centres in collaboration with the Unesco Regional Office for Education in Asia and the Pacific (ROEAP), held in Tokyo from 25 September to 2 October 1984. This served as a consultation meeting of specialists on the applications of data processing as it relates to the use of computers in education.

The Experts Planning Meeting was attended by the following five specialists who had also participated in the Third Asian Seminar on Educational Technology referred to above:

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De La Salle University
Manila, Philippines

Dr. Narong Boonme
Head of Educational Management Information Centre
Ministry of Education
Bangkok, Thailand

The Unesco Secretariat participating in the Meeting included the following staff members of Unesco ROEAP, Bangkok:

Mr Bruce Cahill, Mr A. Dyankov, Mr S. Chu, and Mr J. de Spiegeleer.

The participants reviewed the experiences and current trends in the use of computers in education, considering the likely future applications of computers at all levels of education, both in the teaching/learning process and in educational planning and management.

Newly developed computer software, as well as video tapes showing computer utilization in classroom and other situations, were brought and demonstrated by the participants of the Meeting.

The participants formulated some suggestions for future regional activities, and also prepared collectively some guidelines for the introduction and/or expansion of computer use in education and for the development of computer literacy; which were compiled, further developed and edited by Prof. Jonathan Anderson.

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GLOSSARY OF TERMS

A mobile computer van may provide a cost effective solution for bringing computer education to students especially those in remote areas. Children from schools in Bangkok are seen working on computers in a mobile van on trial in Thailand.

1. INTRODUCTION

CHAPTER OVERVIEW

This first chapter describes the main purposes of this publication which are basically to provide educational policy and decision-makers with an overview of trends and issues in computer education within the countries of the Asia and Pacific region, on the basis of which guidelines for the development of education programmes may be educed. The major focus in the following chapters is on policy issues, considerations of hardware, software development and teacher education and curriculum.

A description is given of the impact that computers have had, and are continuing to have, on society; and the more recent impact that the computer, more especially the microcomputer, is exercising in classrooms of countries of the region.

A brief account is given of the current state of educational computing in the region, a fuller account of which may be found in the milestone Tokyo Seminar of key computer educators in the region.

Finally, reference is made to the Glossary of Terms appended, which is an initial attempt to define important terms in computer education used in this publication.

Scope and purpose

This publication has two chief purposes: first, to provide educational administrators, educational policy and decision-makers, and educators at all levels with an overview of what are seen to be the major trends and issues in computer education in the Asia and Pacific region; and, more importantly, to evaluate some of the basic considerations to be taken into account when introducing or further developing the use of computers in education.

The countries in the region represent a wide range of practices with regard to computers in education and in related technological development. And so it is neither desirable nor appropriate to set forth a set of prescriptive guidelines. Nevertheless, from the accumulated experiences of the countries involved, it is possible to provide a description of practices that represent the current state of knowledge of the field of computer education. It is this description of current state-of-the-art developments - with just a brief glimpse to the future - that might prove useful to all countries, regardless of their state of technological development or their progress along the path towards computer education.

Although computers receive major attention in this publication, it is more accurate to refer to computer-based technologies, since the discussion also centres on computer storage media, word processors, electronic message systems, videotex, communication satellites, and telecommunications. In what follows, the terms "computers", "computer-based technologies", "information technology", and "the new technologies", are used more or less interchangeably to refer to micro-electronics-based technologies where computing and communications come together.

There is currently a degree of excitement about computers in education: many reports are emerging about the educational role of computers; some countries have initiated pilot projects on computers in schools while other countries have established, or are in the process of establishing, national computer education programmes. It was for these reasons that a meeting of experts in computer education was organized by the Unesco Regional Office in Bangkok for Education in Asia and the Pacific (ROEAP) through its Asia and the Pacific Programme of Educational Innovation for Development (APEID). This publication, an outcome of the experts' meeting, is therefore timely.

Many complex issues arise from the introduction of computers into schools - policy issues, considerations of hardware, the development and adaptation of software, and issues concerned with teacher education and curriculum development - not to mention the impact of computers on the general learning process and implications for the structure of the future work-force and of production and services. It is with these issues that the following chapters are primarily concerned; there is an emphasis on the school and tertiary education sectors.

In summary, then, the focus in what follows is on the educational use of computer-based technologies at all main levels of education to meet the needs of individuals and of society.

Impact of computers in education

Of all the new media and new technologies, it is the computer which is attracting most attention. It is worth remembering that the first commercially available computer only came on the market in 1951. Yet it was not this first generation of computers, nor the second, third and fourth generation models that quickly followed, that were to fire the imagination of educators.

The impact came with the development of the microprocessor which was to make its appearance 20 years later in 1971 when the Intel Corporation produced the first computer on a chip to fulfil an order by a Japanese manufacturer of calculators. To many people today the micro-processor symbolizes the "new technology", since it heralded not only the microcomputer but also the automated devices present in so much equipment used in industry, the office and the home. Micro-processors are used also in educational settings as control devices in a wide range of equipment from welders to microwave ovens, digital scribers and photocopiers.

Certainly, what followed that first chip was to lead to far-reaching changes in every facet of life - in international communications, the work place, and day-to-day living - changes described as "the microcomputer revolution". These changes were becoming quite evident at the end of the 1970s.

But meanwhile what was happening in the classroom? Not very much, even in the developed countries of the region, at least not in any large-scale organized manner. Perhaps it was because of economic circumstances since in some countries it might be difficult to justify introducing new technologies in the classroom when more basic requirements like desks and chairs are not readily forthcoming. Perhaps it was also due to the innate conservatism of many educators. One might remember that there was resistance, too, to ball-point pens and to calculators.

One frequent argument therefore related to whether there should be consistent efforts to introduce computers into schools before all schools in the country had been provided with such basic facilities as desks and chairs. However, the winds of change were beginning to blow.

In India the Computer Literacy and Studies in Schools (CLASS) project was launched on the grounds that:

> The information technology revolution is quickly

> sweeping the world... There is, therefore, a great need to expose today's children, who are in primary and secondary schools, to the nature and uses of computers in order to make them capable of coping with the present and the future technological society. Anybody who grows up in the world of tomorrow, not knowing computers, not understanding computers, not being able to use them, will be lost, and that country which does not prepare its citizens to be fully familiar and conversant with computers, their technologies and their applications would not be able to keep its place in the industrial hierarchy in the community of nations (Chandra 1984: vi).

These same sentiments were to see the launch in Australia of the Computer Education Program (CEP) for the period 1984-1986. In Japan, the Japanese National Commission for Unesco in conjunction with the Japan Council of Educational Technology Centres was to turn its focus to computers in education in its third Asian Seminar on Educational Technology in Tokyo in 1984.

The published outcomes of the Tokyo Seminar (Unesco ROEAP 1984, 1985), are key documents and essential reading to all with an interest in computers in education. There it is reported how the computing scene, especially in schools, was beginning to change dramatically in the first half of the 1980s.

Educational computing in the region

There are several accounts within individual countries of developments in schools computing, as the application of computers in education is sometimes called. An Australian perspective, for example, is given in Computing in Schools (Anderson 1984); and a perspective from India is given in the CLASS project noted above (National Council of Educational Research and Training 1984).

The best account of educational computing across countries in the region may be found in Computers in Education: An Outline of Country Experiences (Unesco ROEAP 1985), one of the outcomes of the Tokyo Seminar. This publication describes developments in educational computing in seven countries: Australia, China, India, Japan, Philippines, Sri Lanka and Thailand. As well, there is a separate account of Singapore's efforts in providing computing services. Finally, there is a valuable account of the impact of microcomputers on less-developed countries (Mahabala 1985).

A perusal of the country reports reveals, for the most part, a high degree of enthusiasm for computers in education. From China, for instance, it is reported:

> Enthusiasm is shown throughout the country for the application of computers, especially microcomputers.

The report from the Philippines states:

> Although computer education had a slow take off in the 1960s and 1970s, the present decade shows a significant growth in school computer courses and degree programmes.

Despite enormous difficulties in Sri Lanka (for example, only ten per cent of the schools have electric power supply), the country report notes:

> Cabinet approval was obtained within one week of the Ministry decision to introduce computer education to schools and the type of machines to be bought for school use and for teacher training were also decided at the same time.

From Thailand comes the statement:

> Computer education is now accepted at secondary school. In 1983 some schools acquired microcomputers and started offering short courses as supplements.

Paradoxically, the approach of Japan towards the introduction of computers in schools is best described as cautious enthusiasm, though elsewhere it is reported that:

> The Ministry of Education in Japan seems to be slightly behind in coping with the computer (Iwaki and Hamano 1985 : 52).

In view of Japan's advanced status in chip development, not to say anything of the Fifth Generation Computer Project discussed so much in other countries, another writer (Anderson 1985) was prompted to describe the Japanese situation as "the riddle of computer education in Japan".

There is no evidence, from reports presented to the experts' meeting on computer education in Bangkok (December 1985), to suggest any diminished enthusiasm for introducing computers into schools. From the Philippines comes the comment that given the right economic boost, trends will show continued growth and development. In Thailand a meeting of more than 500 school advisors was convened at about the time of the experts' meeting, its theme Computers in Schools. From this meeting came the strong request for information about software suitable for local languages and conditions. India reported that indigenous software packages have been developed and that 500 schools have been supplied with two microcomputers each as part of the CLASS project. In Australia a national report has advocated the extension of the computer education programme to include primary schools. And from Japan comes the report that a series of training courses have been proposed to prepare teachers for the continued development of computers in education.

Explanation of terms

Every field generates its own peculiar terminology. The field of computer education is full of new terms which may cause a barrier to the uninitiated reader, the terms being drawn from computer science and education.

Already in this section, reference has been made to hardware (that is, the machinery or the computers themselves) and to software (the programs that run on the computers and, without which, computers would be useless machinery). There has been reference, too, to first, second, third and fourth generation computers (which terms refer to stages in the evolution of computers), as well as to fifth generation machines (which is computer science's attempt to develop a "thinking" intelligent machine).

To assist readers, a Glossary of Terms in computer education has been compiled and is included in an Appendix. Some of the terms like expert systems are very new and are not easily located in other published sources. Quite a long description of this term is given because of its perceived importance in likely future computing developments. Rather than interrupt the flow of the text, all technical terms referred to are located in Appendix A. The compilation of this Glossary is a new endeavour and one which may merit extension in the future.

2. CURRENT AND FUTURE DEVELOPMENTS IN EDUCATIONAL COMPUTING

CHAPTER OVERVIEW

This chapter commences with a brief overview of educational computing as it is at the beginning of 1986. This overview, in conjunction with Chapter 1, provides educational planners and policy makers with a synopsis of the here and now.

The major part of the chapter looks at likely future developments in computing, communications, video disk and robotics. It is these developments that educational planners and policy makers must take into account, too, since planning for the present will be to provide systems with all too short a life.

Finally, there is some discussion of research. The needs here are great and urgent, for new hardware and software are appearing more rapidly than schools' capacity to evaluate them. One research project identified as a priority is to evaluate the effect on students' learning processes of working with computers; another is a feasibility study on how best to introduce the use of computers in education.

Introduction

In planning to introduce computers into schools, or to further develop the use of computers in education, it is sensible to see how computers are currently being used. This chapter commences, then, with an overview of the current scene as seen through the eyes of those who have been deeply involved in the schools computing field. These current developments are those pertaining to the beginning of 1986.

But in a field as fast changing as computer education, it is necessary also to look to the future, difficult though this may be, and try to anticipate possible future developments. The major part of the chapter, therefore, examines developments on the horizon, developments which are fast becoming the current scene of today.

Current scene

The use of computers in schools has been recognized as a way to improve learning (making the education process more efficient) and also to enrich the education process. However, its implementation is quite varied across the countries in the region. Whereas one sees a proliferation of computer access in a classroom in developed countries, the introduction of computers, even at professional educational levels, is non-existent in other countries. Manufacturers have launched subsidized programmes in some parts of the world to encourage schools to acquire microcomputers. In other countries governments have offered subsidies to schools. Another difference is that some schools have used standalone microcomputers, while others have used local area networks or even a number of terminals connected to a main processor.

Some countries have developed mobile vans with a set of work stations which can be moved from school to school. Recently introduced microcomputers for schools have invariably had disk drives and the option of colour monitors, whereas some of the early machines, which are still very effectively used, have only black and white monitors and cassette tape for auxiliary storage.

There is also wide variation in the levels at which computers are introduced in the curriculum. With the wider availability of good software packages, computers are being introduced to a student as early as possible (even in the first year of school).

The purposes for which the computer is used range from literacy (learning about the potential of the computer) to Computer Based Learning (CBL) where the computer can enrich student learning. Of course, there are also Computer Studies courses which deal, for instance, with learning about computers.

There have been arguments about whether it is better to introduce computers to students through teaching a programming language or through the use of well designed generic packages (such as Word Processor, Data Base, Graphics, and Spreadsheet). Perhaps there was no alternative other than to 'go the programming way' in school systems where computers were introduced five years ago. Today some of those school systems are wanting to switch over to general applications packages, especially where they want to introduce computers at the primary level. It is now more or less accepted that the choice of a computer for a school depends a great deal on the availability of educational software packages.

It is interesting that in some technologically advanced countries, where one would expect a proliferation of microcomputers in schools because of the advanced status of the computer industry, there is still debate about whether to introduce computers in schools, and if so, what mode will be best for the overall education process.

It must be recognized that it is too early to establish through analysis of actual data, what the overall benefits of computerization of schools will be. There must be positive and negative sides in that assessment. However, many countries are interested in introducing computers in schools since they feel that the child of today must be better equipped to cope with life in the high-technology society of tomorrow. Some of them even think that unless governments make an effort to introduce computers to underprivileged groups (rural, low income, non-English speaking, and so on), the gap between children from affluent communities and the average student will widen further, thereby creating further problems. To them it is not the 'why' but the 'how' of computerization.

Looking ahead

For educational planners it is useful to try to look, perhaps to the next five years and into the next decade. However, in a field as rapidly changing as computer education, this is an exercise fraught with difficulty.

If we look back at forecasts made in the past ten to fifteen years about the use of computers in education, O'Shea and Self (1983) note that there is not a close match with current practices. In the United States, for example, there were many predictions made in the early days of computers that routine computerized drill and practice in schools and universities would be in almost universal use by 1979 and that more sophisticated learning programs would supercede these over the next ten-year period.

In Britain, by contrast, the Council for Educational Technology in 1977 did not foresee any revolution in computer education, since computers would "remain obstinately expensive". Even Toffler, author of that best seller of the 1970s, Future Shock, not only failed to predict the impact the microprocessor would have on society but failed to mention microprocessors at all. The simple explanation - the date of his manuscript (Toffler 1970) predated by a year the invention of the first chip by Intel in 1971).

O'Shea and Self concluded that most predictions about educational computing have been "either wildly over-optimistic or over-pessimistic" (1983 : 260).

With caution, then, we look forward to the remaining years of this century. Developments that can perhaps be foreshadowed with some degree of certainty in the medium to long term are the advent of fifth generation computers, the coming of age of artificial intelligence, and the increasing sophistication of expert systems.

Likely future developments

Reduction of hardware costs - increased sophistication. The most important development is the availability of large amounts of semi-conductor memory at very low cost. With this development, the memory bottleneck disappears. However, some existing 8-bit systems cannot effectively use more memory, and so there is bound to be a migration to 16- (or more) bit machines. Further these processors also make it possible to use more sophisticated software and still have reasonable response times.

Colour monitors will become cheaper and standard. Since many CBL educational software packages use animation, one can expect to attach specialized graphic processors. Advances in software technology for interactive programs (menu and multiple-window based) will use a mouse device for some types of inputs. The use of a mouse will enable the introduction of computers at even the pre-school level. Auxiliary storage will become quite crucial and one can expect Winchester disk availability on low-cost microcomputers. Moreover, three inch floppy disks are increasingly being used and seem likely to emerge as the new standard for disks.

Video disk memories (large capacity) will perhaps become available, particularly for read-only encyclopaedic-type data bases. One can very well expect the Encyclopaedia Britannica and other information bases to be available on video disk for query and browsing by a student. Video disks are already part of arcade games.

It is expected that laser printers will become more commonplace. School systems can expect to have access to low-cost laser printers especially in systems serving non-English scripts. Printing in any script is very easy with a laser printer (it can also be done on current plotter printers).

Computers and communication. Some countries are distributing software by broadcast. In other words, just as the air waves can be used to transmit sound and pictures, so can digital signals similarly be transmitted. In this way, each system need not have its own expensive auxiliary storage. This use of broadcast to transmit software can be expected to grow.

Computers and communication are coming closer. In fact one cannot progress much further in the one field without recourse to the other. One can expect communication to become integrated with the classroom computer in the same way it is happening in offices through the use of local area networks (LAN). A student will be able to communicate with other students or the teacher by electronic mail. Some measure of this is already available on some custom networks. But, more importantly, one will see a generalization and enhancement of communication capability. This communication linkage will extend to connecting to public communication networks within a country, and beyond. One might very well expect a child learning a foreign language to participate in a link comprising software/teacher/student with a country where the language being learned is the native language. Students will also be able to browse through the collections in the national library many miles away.

Voice input and output will become available. It is natural to expect that school microcomputers will be used for more than text handling. Small, specially designed robots will be attached to the computer to enable students to learn planning of complicated actions and also to make some simulation studies more effective.

An extension of attaching robots to computers is to provide systems for educating the handicapped. Computers can be successfully used in special education. Perhaps the vital role of computers in this direction will be more fully realized in the years to come and some feel that all handicapped will find a way to lead useful and productive lives by use of specially designed computer based systems. Since such people cannot afford to pay the commercial cost of developing such systems, an international framework to disseminate both available experience as well as 'how-to-do it' manuals is very necessary.

CAI, CBL and CBT. From the beginning computers have been used as a medium for programmed instruction. A piece of information may be presented to the student and perhaps a quiz is given immediately thereafter. Another use is the drill and test mode. These uses come into the category of Computer Assisted Instruction (CAI). At a later stage, computers were used to convey concepts which routine teaching using traditional media cannot. In this way computers enriched teaching, or made it more effective and this general mode is referred to as Computer Based Learning (CBL). However, some believed that the main advantage of a student working at a terminal was not fully exploited to provide personalized attention to the student. Recent advances in knowledge engineering promise new types of software which capture the role of the computer as tutor to a student. This mode, referred to as Computer Based Tutor (CBT), will become more prevalent. It is necessary, however, to emphasize that the three modes described here, CAI, CBL and CBT, will be used to cover the various aspects of student-teacher interaction.

Video technology. Video technology has become mature and affordable with the availability of low-cost video cassette players (VCP). One can expect computer-based education to take full advantage of these advances through the attachment of VCP's to computers for perhaps showing some information effectively through a sequence of still images. Video disks will be better suited for this purpose, as evidenced by their use in arcade games. There was talk in the early days of a multi-media approach combining computers, slide projectors and audio cassettes. Today there is the realization that the approach is more effective through a combination of computer, graphic terminal, speech synthesizer and video cassette player (or video disk).

A trend is seen in which authors of textbooks provide software on a diskette to enhance the learning value of the text. One can very well expect this trend to grow and school textbooks to have associated computer software for exercises, self-evaluation and testing understanding of concepts.

Teachers and computers. There is a concern among some about the role of a teacher when computers are introduced into schools. It is a mistake to think that the replacement of teachers is the goal of computer education. It should be emphasized that the teacher, if anything, becomes more important in getting the most out of the investment in computers. Activities that a teacher does not have time for because of the many other conflicting demands of teaching, such as finding time for drill and routine testing and evaluation, or for tutoring to provide individual attention, will be taken care of by computers. Also a teacher can use computers to increase understanding of difficult concepts in a course through specially tailored CBL packages. Thus the computer in education complements a teacher and makes the education process closer to what education experts believe should be available to each child, particularly those experiencing learning difficulties.

The need for research

The world does not have enough experience in the use of computers in schools. Although technology has been changing rapidly in an effort to bring down costs and give more capability, there has not been the opportunity to adequately evaluate children who have been exposed to computers. Countries do not as yet have the first batch of students who have gone through the computer route.

However, enough pilot projects are in progress in various countries and it is very necessary to share those experiences for the benefit of all. An approach is needed whereby the wisdom that has been gathered at considerable effort, is made available to other countries. For example, India is attempting to introduce computer literacy to students of varied backgrounds, rural to urban, non-English speaking, average to English speaking, bright to poor, girls and boys, affluent to economically backward. It is important to disseminate the experiences gained in that experiment. One cannot apply the usual techniques for evaluating the effectiveness of such experiments - for judging the effectiveness of education does not lie only in evaluating the student but also the quality of educational inputs to him. There is need to involve a multi-disciplinary group of experts in such evaluation.

Adaptation to local languages. Adaptation to local language/script has been considered an essential aspect of introducing computers into universal education. It is not a matter of inventing languages like FORTRAN or BASIC in a local language, but rather the ability to perform input/output and word processing in local script. Considerable progress has been made in adapting to local script. Software methodologies are available to adapt software to new script. It is necessary to disseminate those experiences and methodologies between countries so that those countries wishing to make a start with the introduction of computers in schools do not need to re-invent the wheel.

Mention has been made above to the Fifth Generation Project in Japan. It is interesting that the Director of this project, Dr Fuchi, expects the results of the Japanese research will have its greatest impact on personal computers:

> The real impact will be on the computers that are readily available to people - personal computers - rather than mainframes or supercomputers. The purpose of this project is to develop basic technology. Then, using this technology, you can make big computers and you can make small computers. But it is more important for the world to apply it to the personal type (Quoted in Ahl 1984 : 113).

If Dr Fuchi is right, that the impact of this national research effort will be felt on personal computers similar to the kind currently in schools and universities, then there are obvious implications for education.

Significantly, as far as schools and other educational institutions are concerned, it means that there is a breathing space to prepare for the arrival of the newer generation of computers. It is important not to lose the opportunity offered for there is much that is not known about students' interaction with the current generation of microcomputers. The need for research of all kinds is therefore great.

A research agenda needs to be developed. Some questions to be placed on this agenda include:

* What is the impact of computer-based studies on the long-term development of the child?
* How does time spent at the computer affect student learning?
* What is the impact of computers on curricula?
* How are attitudes of students towards learning affected by computers?

- What type of software seems to work best?
- Where are computers to be located?
- Does the placement of computers in a school affect how they are used?
- What is the role of the computer in educational management?
- What is its role in testing?
- How should teachers be prepared to teach with computers?
- Are there minimum, maximum and optimum times that students should work at computers each day?

Emerging from these and other questions are suggestions for a number of research and development projects which might be undertaken, foremost of which is:

- The impact on students' learning processes (cognitive and affective) of working with computers.

Other projects which might also be undertaken (not in any order of priority) include:

- The usage of microcomputers in educational planning and management.
- A comparative analysis of curricula for introducing computer literacy at both primary and secondary levels.
- The needs of CAI or CBL in teacher training.
- The attitudes of teachers, generalists and subject specialists, towards computers.
- The use of different types of keyboard (e.g. QWERTY vs Dvorjak) and other input devices (e.g. mouse, light pen, touch).
- The use of the computer in non-formal education.

* Evaluative studies on:
  - effects of changing employment patterns due to the introduction of computers;
  - the impact of computers on curricula; and
  - the use of computers by special groups (the disadvantaged, the handicapped, the gifted, and so on).

* The adaptability of software "shells" across language and regional groups.

* Collection of literature on ergonomic considerations.

3. EDUCATIONAL AND POLICY ISSUES

CHAPTER OVERVIEW

In this chapter are brought together some of the key issues to be faced in embarking upon a nationwide computer education programme. The issues for policy makers resolve around six main areas:

Hardware
Software
Teacher education
Curriculum
Research
Support services

While these areas are covered in more detail in the following chapters, this chapter focuses on broader issues cutting across all areas.

The relationship of schools to society needs to be considered at the outset. In view of the enormous impact that computer technology continues to exert on society, it must be for schools, as society's agencies, to prepare the citizens of tomorrow with the skills needed to cope in a world where computer-based technologies are increasingly pervasive.

One of the major new skills will be the ability to use the new electronic information services made available through computers. All students need to know how to access these new sources of information.

The needs of special groups of students have to be specially considered if the goal of equity to all students is to be served. The special groups include girls, the physically disabled and students from disadvantaged areas or circumstances.

Another special group, who may be disadvantaged unless special provisions are made, are those students who live in geographically isolated communities, including rural areas. Several experimental projects in the region indicate how technology may bring education to students living at a distance from population centres.

To meet the needs of all students some time during their careers at school, it is important to determine at which levels in schools to place computers. Various options are discussed.

Obsolescence of equipment is an additional problem facing policy makers in the rapidly changing world of computers. Coupled with this are associated problems concerning compatibility of software. There is discussion of these problems to do with obsolescence of equipment and the suitability of software.

Other issues, of which policy makers need to be aware, concern security and privacy of information held on computer, copyright, and general health considerations relating to use of computers.

Computers play an important function in the conduct of modern businesses. Not always recognized, is the fact that the school is a sizeable business, and there is discussion of some of the functions of computers in school administration.

Along with the needs of formal education is the need to raise computer awareness in the wider community. Here television can serve a useful function and some significant projects are described.

The latter part of the chapter deals with issues that extend beyond education to include such ministries as industry, labour and employment, and finance. In particular, there is some discussion of the promotion of domestic industries and the general question of cost and financing a national computer education programme. It is unrealistic to expect all funds to come from central government. Parent bodies and professional organizations have acted effectively as support groups in some Member States.

Introduction

The field of computer education is a rapidly changing one. The speed of change, together with the fact that many senior educators have not themselves become familiar with computer-based technologies, has caused a number of quite complex policy issues to arise with regard to the use of computers in education.

Because of the longer experience of some Member States in computer education, what may be considered by them to be an important issue at any one time, may not be an issue at another time nor may it be an issue in other countries. With this caution, a brief examination is made in this chapter of what appear to be the major issues relating to the educational use of computers across countries. The listing that follows is not in any way exhaustive; nor is it in any order of priority since country experiences vary quite widely.

But first the key areas of national policy should be examined and the place of computer technology in schools and society.

Areas of national policy

For those countries wishing to formulate a national policy on computer education, there are certain areas with which such a policy might be concerned. Following Cerych (1982), these areas revolve around the following six headings, which could constitute a checklist for providing financial and other support.

1. Hardware - that is, the kinds of computers to install in schools, as well as appropriate furniture and other physical facilities.

2. Software - that is, the computer programs and accompanying learning materials (called courseware or lessonware) needed for

learning about, or with the help of, computers.

3. Teacher education - that is, initial or in-service education for those who, at various levels, will be in charge of introducing students to the world of new information technologies.

4. Curriculum - this involves, among other things, the inclusion of pilot experiments concerning any aspect of the integration of computers in the content of the curriculum.

5. Research - on all aspects of the use of computers in education including their effect on students' learning behaviour and the changed nature of interactions in classrooms.

6. Support services - that is, the exchange and circulation of information on new approaches, quality control and storage of software, advice and guidance to schools and teachers, and maintenance of hardware.

According to Cerych, "how many components a national policy should ideally take into account will depend on the nature of the political, constitutional and education system in a given case" (Cerych 1982 : 19).

The three chapters which follow deal with the first four areas noted above, that is with hardware, software, teacher education and curriculum development. The remaining two areas, research and support services, are discussed, where appropriate, within all chapters.

Computer technology, schools and society

As noted in Chapter 1, computer technology has had an enormous impact on society and is affecting the way society is structured. For democratic societies, the major goals must be to provide equal opportunities to all members of society. This means that computers, as new communication tools, must be made accessible to all. Since schools are society's specific agencies for providing equality of access, it is upon schools that the responsibility for introducing tomorrow's citizens to the new modes of communication lies.

Technology in general, and more especially computers, offer opportunities for individuals in society. In some countries of the region, the projection has been made that by the 1990s a majority of the work-force will be employed in the information sector. In addition, individuals might use and benefit from computers as personal tools. For these kinds of reasons, computers are justified in schools - to learn about as a social phenomenon, and to learn with or from as general purpose tools.

Equity of access to information services

Arising from the preceding discussion, schools have a responsibility to provide all students access to the new electronic information services via computers. A number of countries now provides public information services. The earliest example is Prestel established in the United Kingdom in 1976. More recently, countries in the Asia and Pacific region have established similar services, notably Japan with Captain in 1984 and Australia with Viatel in 1985. Besides these public information services, there are many private services which provide all kinds of financial information, information about stocks and shares and futures trading, information about farm management, just to name a few areas.

All these information services, whether public or private, are embraced in the generic term videotex. If general accessibility to videotex is not to widen the gap between the 'haves' and the 'have-nots' across the region or within countries, nor to create groups of 'information-elite' and 'information-impoverished', then schools must teach students how to access such services. To be denied the information now available from today's electronic sources is to leave people vulnerable and powerless.

Equity and the needs of special groups

There are many aspects of the equity issue besides the general question of access to new sources of information via developments in telecommunications. We might separately identify the special needs of girls, the needs of the physically disabled, and the needs of those in less affluent communities.

Girls and computers. There is a tendency in most countries in the region for boys and men to be the predominant users of computers. Girls and women tend not to become involved, perhaps because emphasis has in the past too frequently been placed on the hardware (the machine), and women have traditionally stayed away from machines. If, however, computers provide access to new sources of information, as has been argued above, it is important that schools should not disadvantage half the population.

In many countries there is a trend to suggest that computers are currently used mostly by teachers of mathematics for such activities as programming and computer studies. There is need for concern here if girls, because of a general preference for non-mathematical subjects, should thereby have fewer opportunities to use computers.

The physically disabled. Students who are physically disabled have different needs from other students. It has been shown that computer technology can alleviate these disabilities. For many such students, especially the cerebrally palsied and the multiple-handicapped, microcomputers are providing new means of overcoming physical limitations and, according to Wood (1985), this leads to the computer being used not only as a learning tool but also as a means of communication.

Specially developed software permits moderately disabled students to interact with computers by pressing just a single key at the keyboard; for those with more severe handicaps, a simple switch, either air cushion or rocking lever type, allows students to respond to visual signals on the monitor.

Promising starts have been made in the application of computers to meet the needs of handicapped students. But much yet remains to be discovered about the most effective modes of delivery and the needs for developing both hardware and specialized software are considerable.

Less affluent communities. There is a trend to indicate that more affluent school communities (in those countries where education is largely decentralized) are purchasing computers in greater numbers than school communities in poorer areas. In one school in the region, for instance, it was reported that computing equipment included ten Macintosh microcomputers, 63 Apple IIe and IIc microcomputers, an assortment of other brands, as well as a Vax 750 minicomputer. While this school is certainly not the norm, it is not the best endowed in the region. The school's Director of Computing was reported as saying:

> We see the computers as a vital part of our educational services and believe that our students must be prepared for the technological world they're entering (Apple Computer Australia 1985 : 6).

This tendency for affluent schools to acquire computers more readily, compounded by the fact that students from such schools are also more likely to have computers at home, points to yet another imbalance for the education system to seek to redress. It may suggest a need in some countries for a policy of positive discrimination to assist schools in less affluent areas.

The issue noted here may be further compounded by the fact that computers are often used differently in lower socio-economic societies. In higher socio-economic areas, for instance, computers are introduced as a personal tool, as a resource to learn to use to promote higher order thinking skills and enhance creativity; whereas in lower socio-economic areas computers are used more often for drilling students. In one case, students program the computer; in the other, the computer programs the students.

Equity and geographical isolation

The geographical location of schools is yet another issue with implications for policy. In several countries of the Asia and Pacific region, problems of distance and isolation mean that equality of access to educational services is a major concern. As a result, many institutions in the region have become pioneers in distance education.

Thailand's Open University, Sukhothai Thammathirat for instance, has no classrooms and relies heavily on various technological teaching media for instruction. In other places, new communication techologies are being used to bring education to students in outlying communities. As early as 1975 India began using satellite communications for instruction in an experimental programme known as Satellite Instructional Television Experiment or SITE. Papua New Guinea, and New Zealand too, have used satellite to provide in-service education to teachers and administrative officers in a project called Pacific Educational and Communication Experiment by Satellite (PEACESAT).

Levels of education to receive priority

With limited resources and funds, a contentious policy issue is to determine priorities in placing computers in schools. Questions which arise include the following:

1. At the national or system level, are microcomputers to be placed in secondary schools before primary schools?

2. In secondary schools, is priority to be given to the upper secondary level, or to the last year of compulsory schooling to prepare students about to enter the world of work, or to the lower secondary level in the form of computer awareness courses?

3. In primary schools, is priority to be given to students in the upper grades?

The question of which levels of education should receive priority is not unrelated to how computers are used in schools. If, for example, a policy decision is made to place computers in the senior secondary years, this often implies that computers are used for computer studies or computer science. This is not the case, however, in the CLASS Project in India where the main focus is on the applications of computers.

In most countries of the region, the emphasis is to place computers in secondary schools before primary schools. Strong arguments are nevertheless being advanced to place computers in primary schools, as evident in the report Teaching, Learning and Computers in Primary Schools (Commonwealth Schools Commission 1985); and computers are already in use in many primary schools in some countries.

Obsolescence of equipment

Two views may be taken with regard to obsolescence of equipment. The first, drawing an analogy with the motor car, holds that just because a particular model has been superceded, it does not mean that the previous model may not still be used. So, similarly, it is argued that computing equipment may continue to serve a useful function even though newer models are now on the market. To continue with the analogy of the motor vehicle, the second view holds that if, for example, fuel were to change from petrol to, let us suppose, some more efficient substitute, the vehicle might only continue to run with some expensive modification and then less efficiently than before. The appearance of newer, more powerful microcomputers bring in their wake more efficient operating systems or languages to drive them and thus to continue with older models is inefficient. Both views have some validity.

With hardware, the current market place is witnessing a severe shake-out with some companies retreating from the educational end of the field (e.g. companies like Texas Instruments) and other companies (e.g. IBM) making determined efforts to get a slice of the market. The result is that there is a wide range of companies competing for the educational market with a variety of different models; and some of the companies and models will not survive. There is the possibility of the Asia and Pacific region being a dumping ground for computing equipment that has been superseded elsewhere.

Nor does it seem likely that the situation will stabilize in the near future. Yesterday's 16K machines have all but been replaced by today's 64K and 128K machines (and the day before's 4K machines have long since gone). And today's machines will soon be supplanted by tomorrow's 256K and larger supermicros. In addition, 16-bit microcomputers are beginning to compete with the 8-bit machines mostly found in schools today.

Perhaps it is the battery powered microcomputer, yet to be seen anywhere in significant numbers, that will have the greatest impact on schools computing. It will be a special advantage in rural areas where there is no electricity network.

All of this is not an argument to delay the introduction of computers in schools since the rapid rate of change seems certain to continue. Educational policy makers, however, need to be aware of the changing state of the market and the consequential educational implications.

Suitability of software

The real problem about the range of hardware is the lack of any standard operating system. This is why software or programs written for one machine will not run on another machine. Sometimes software written for one make of microcomputer will not run on newer models of the same microcomputer. And sometimes even software designed for one model will not run on the same model in another country because of varying hardware specifications. So-called compatible microcomputers are not able to run all software designed for the microcomputer for which compatibility is claimed.

The problems of compatibility of software are ones of which educators must be aware. The wise counsel is not to believe a vendor's claims about compatibility unless these are demonstrated and the software is seen to run.

There are other aspects of software suitability which are covered in a later chapter. For the present discussion, it may be noted that, in the same way that obsolescence of hardware may be a barrier for educational institutions, similarly obsolescence of software may be another barrier. As happens with other teaching and learning materials, new editions of software are constantly appearing, incorporating improvements or taking advantage of the greater memory capacities of newer models of microcomputer. Thus, when speech, for instance, becomes a normal part of computer programs, today's 'silent' software will become museum pieces, in very much the same way as the old silent movies.

Security and privacy

Just as other areas of human interaction have given rise to fraudulent practices, so has the use of computers given rise to a range of new crimes. Reports of unauthorized entry into the computer databanks of financial institutions and of the military are becoming commonplace. Security of data where the data may represent the transfer of funds from one account to another, or perhaps the modification of examination marks, or maybe the destruction of particular records are alarming developments which are a direct consequence of increased knowledge about computers and the proliferation of personal computers.

Closely associated with data security is the question of individual privacy, which involves unauthorized access to, and the misuse of, personal and confidential information held on computer.

Other related questions that might be considered here, are software piracy and copyright, which are emerging as complex legal issues. All of these areas are cases where the law has not kept pace with advances in technological development.

The policy implications for education arising from questions of data security, individual privacy, software piracy and the breaking of copyright are that these impacts of the computer on society are yet other areas which students should meet in schools.

Ergonomic and health considerations

In clerical-based occupations, there is mounting controversy in more than one country in the region about what is variously termed repetitive strain injury (RSI), tenosynovitis or, simply, overuse injury; all terms being used to describe injuries sustained through repetitive movements involved in extensive use of certain limbs. This interface of humans and tools or machines is sometimes called human factors engineering or ergonomics.

With the increasing use of computers in schools, the possibility exists for students to suffer from the same kinds of injury and thus ergonomic considerations are looming as issues on the horizon. As O'Hanlon (1985) notes, "one of the ironies of computer technology is that what was originally meant to reduce repetitive tasks has lead to an increase in injuries exacerbated by repetitive movements".

Besides strictly ergonomic questions, there are more general health considerations relating to eye strain and injury through prolonged monitor use, or non-stable and flickering images, or poor lighting and glare.

Questions of furniture design should also be considered here since the height of desks relative to the placement of the hands, and the type of chairs and backrests are known to induce postural strain.

Just as ergonomic and health considerations are currently important in computer installations involved in extensive data entry, so might they be expected to be potential problems in the field of computer education.

Computers for management

While the major emphases in this publication are on computers for learning and teaching, it must be recognized that computers have an important function to play in management. The education system is a huge enterprise which deals with large numbers of students, teachers, equipment, materials and facilities. Efficient management of these resources, as in any major business, requires an effectively organized information flow in the system, a carefully thought out plan in the short- and long-term, and strategies for implementation.

What has been said of the information system as a whole, applies no less to schools. Indeed, many schools are larger than a range of businesses which routinely use computers for management. Some functions of computers in school administration include staff and student records, inventory control, timetabling and scheduling, financial transactions, attendance records, enrolment information, students' academic results and age-grade statistics.

The use of computers for educational management is of great interest in every country in the region and is requested by administrators in every section of the educational system. There are implications here for training courses for school administrators.

Computer awareness in the wider community

Most of the preceding discussion and, indeed, most of this publication focuses on the needs of formal education. However, beyond the ages of formal education (school and university), there is a large population whose need for knowledge about computers ought to be considered. There are many avenues for raising computer awareness in the wider community of which schools and universities are a part.

In countries like Japan, industry has always assumed responsibility for on-the-job training, and this includes the use of computer-based equipment. The printed media, newspapers and magazines, are also contributing to general awareness of computers by giving a wide coverage to the new technologies. Vendors of computing equipment are helping to raise community awareness by their displays and through advertising. So also are computer societies and associations, and this is taken up in greater detail below.

Possibly the most effective way to raise computer awareness on a nationwide scale is through television and video. This was ably illustrated in the Computer Literacy Project in Britain. First came the BBC Horizon television programmes "Now the Chips are Down" and "The Silicon Factor". These were followed by two ten-part television series "The Computer Programme" and "Making the Most of the Micro". An important part of the BBC Computer Literacy Project was the selection of a microcomputer so that users could be offered hands-on experience. Computer companies were invited to submit designs and the contract was awarded to a Cambridge company, Acorn. So birth was given to the BBC microcomputer, now widely used in several parts of the world including Australia and India.

All the BBC television programmes noted above have been televised on the Australian ABC. Such programmes and the popular "Beyond 2000" series have done much to increase community appreciation of computer technology. Japan, too, has announced that it is producing similar programmes which will be televised nationwide early in 1986. Videotape programmes or broadcast programmes have the potential to reach wide audiences and there is merit in an interchange of experiences, and possibly materials as well among Member States in the region.

Promotion of domestic industries

The use of computers in education is stimulated not only by pedagogical factors but also by industrial and employment needs. In many countries, the ministries of industry and labour and other similar ministries, have collaborated with the ministry of education to the mutual benefit of both education and the economy. The United Kingdom experience, where the department of education and science on the one hand, and the department of industry on the other, came together in the Computer Literacy Project, has already been noted in this chapter. Under this scheme British schools could purchase any of three British-made microcomputers on a pound for pound subsidy. The French experience is similar.

In some Member States educational and technology task forces have been formed to gauge the needs of education and industry and to make recommendations to government. A considerable investment is required for the introduction of microcomputers into schools and collaboration between financial institutions, ministries of labour and industry, and promotion commissions, can promote domestic industries within a national policy of economic and labour affairs.

Cost and financing

Experience within those countries, which have embarked on national computer education programmes or projects of national significance, show that the costs are such as to require funding from the central government. This is not to suggest that the funds need necessarily come from the education budget. In the United Kingdom, for instance, funding for the purchase of a microcomputer in every school came jointly from the Department of Education and Science and the Department of Industry. This point relates to the promotion of domestic industries discussed above.

There are several calls on the funds for a national computer education programme. Obviously, one of the first costs, at all educational levels from primary to university and adult education, relates to the purchase of hardware. Not only are there initial purchase costs but there must also be budgeting for maintenance and replacement of equipment.

Just as important as funds for hardware - some would argue more important - are funds for software development and teacher education. Too many promising educational innovations have withered at the vine because of a failure to prepare teachers adequately. But in the case of computer education, the most expensive hardware will achieve nothing without the appropriate software to drive it.

It is not realistic to expect all funds to be forthcoming from central resources and it will be necessary to involve community resources also. Currently, enthusiasm among students and among parent bodies in some quarters, is providing the motivation to raise funds to assist in the purchase of hardware and software. For example, the utilization of students' income-generating activities to acquire funds for computer hardware and software may be combined with parents' profit-generating activities. There is all the more reason, then, to ensure that teachers are adequately prepared and feel involved.

The role of professional organizations

In each country, associations may play active roles as agents of change and innovation. They may also serve as strong pressure groups so that government may introduce new policies and directions. What follows is a case study of two organizations which have acted effectively as pressure groups in the Philippines.

In the Philippines, the Philippine Computer Society has emerged as a strong organization in influencing the government to introduce new directions and policies in computers. Formerly a predominantly social organization, the Philippine Computer Society has conducted industry studies, sponsored conferences, published articles by its members and facilitated the co-operation of different organizations to form an acceptable software and service industry.

Through its efforts, the society has influenced the government to produce Letters of Instructions 1380 and 1381. This paved the way for the creation of a Cabinet Committee on Computers, together with a Technical Sub-Committee with representatives from government, education and industry.

Another organization that has strongly influenced computer education in business schools is the Philippine Association of Colleges and Schools for Business (PACSB). Through its own initiative, following the recommendations of the organizations which hire their graduates, PACSB revised its standard curriculum to include computer and computer-oriented courses up to 21 units in the accounting programme. It has also co-operated with leading universities such as De La Salle University to implement an extensive teacher training programme nationwide. This programme is now in its fourth year of implementation with many of the teachers who undertook the programme, now conducting their own training.

4. HARDWARE CONSIDERATIONS

CHAPTER OVERVIEW

The purchase of hardware requires careful planning. In evaluating and selecting computers, key questions to ask are: Who are the users? How will computers be used? What are the tasks that need solving? How will computers help in the solution of these tasks?

Costs of computers vary widely depending largely on the size of the central processing unit and memory, the number of attachments to be connected, and expansion capability. In determining what sized computer is needed, it is important again to consider the proposed uses, especially administrative uses.

It is not always the case that centralized location of computing resources is the best way to place computers in schools. There are consequential advantages and disadvantages to both centralized and decentralized locations and the preferred option depends on how the computers are to be used.

The preparation of a site or sites involves considering such factors as furniture design, safety and security, electrical wiring, and the appropriate environment for both electronic equipment and users. It is important to try to anticipate future needs at the time of initial installation.

Maintenance of computing equipment is a continuing operation and three commonly used alternatives are discussed.

Some adaptation of both hardware and software is usually required to suit local conditions and the reliability of the supplier to provide continuing support should be considered.

Once equipment is installed, care needs to be taken to ensure proper management and control in the usage of the computing facilities. This has staffing implications.

The graphics and other special features of computers, such as plotting capability, sound effects and use of colour, are yet further factors to take into account. Another is insurance, not only of physical facilities but also of hardware and data.

The chapter concludes with a short checklist that serves to highlight the major considerations involved in hardware selection.

Introduction

This chapter discusses some of the many considerations to take into account in selecting or purchasing hardware for schools or universities. Many of the considerations are similar regardless of the educational level and, for this reason, school is used throughout this chapter to refer to both schools and universities.

Acquiring computers for schools is not as easy as acquiring typewriters, calculators, tables, chairs, and so on. There are many considerations that should be looked into so as not to waste financial and human resources.

In general, a school acquires computers for any or a combination of the following reasons:

1. teaching and learning
2. research and community service
3. administration

Depending on a school's needs, it may come up with evaluation criteria from which decisions on the model, brand, quantity and configuration will be based.

For whatever reasons a school decides to acquire computers, there are factors that should first be considered before any actual acquisition. Considering these factors may minimize the problems and disappointments which accompany wrong or hasty decisions.

Evaluation and selection

Evaluation and selection of computers is a complicated task which, if done properly, may save the school time, money and headaches.

The first step that should be undertaken by the school is assessment of its needs. Some of the questions that should be raised are: Who are to use the computers? What are they to be used for? What specific problem areas need to be solved? How is it perceived that the use of computers will solve such problem areas? Unless such questions are raised and answered, schools should avoid getting computers.

Usually, the factor that triggers the need for computers is pressure from the students, parents, other schools, industry or government. These pressure groups are real and will make the school start looking at computers as tools. However, school administrators should first have a clear understanding of computer technology prior to acquiring any computer facilities. In order to have the necessary knowledge and understanding of how new computer technology can be used in schools, school administrators should read appropriate literature, attend seminars, discuss with other administrators with experience, identify faculty and staff who are knowledgeable, engage consultants, and/or inquire from suppliers. It is advisable that integrated information be available to them so that they can personally participate in the evaluation and selection processes.

The school could then come up with a plan that is discussed and understood by everybody who will be involved in the implementation. Although this is a time consuming task, the amount of time and energy that is spent in order to make a good choice of hardware will prevent major headaches later.

The plan could include the required budgetary allocation for the acquisition and other incidental expenses needed. A 3-5 year time-frame for expense and income projections will be realistic although some schools may be able to extend the lifetime of their computer facilities up to seven years. The plan should also consider whether the facilities will be centralized or decentralized.

Costs

Buying computers is a major capital outlay and involves complicated analysis, because the cost of hardware varies depending on size, brand and model, what peripherals are included, and expansion capability. It also involves analyzing the vendors one is dealing with and their performance in the market.

The major components that should be looked into are the central processing unit (CPU), memory storage devices such as disk drives and tape drives and peripherals such as printers, monitors and plotters. Other cost components which may not be so obvious at the start are cables, controllers, add on features such as memory expansion boards and graphics cards.

Computer size is usually associated with memory capacity. However, this is not the only consideration when one is looking at computer capacity.

It is common to classify computers as microcomputer, minicomputer or mainframe computer. Nowadays, the capabilities of micros are becoming so great that they are overlapping with minicomputers (minis) and likewise, minis are becoming so powerful that they are overlapping with mainframe computers.

The trend today is to link up micros with minis and mainframes in local area networks so that all machines can communicate with each other.

The costs of these three different classes of computers vary from a hundred dollars or so for the cheapest microcomputer to millions of dollars for the larger mainframe computers. What you pay for is increased computing capability.

For school purposes (especially, small schools), microcomputers are perceived to be the cheapest and most cost effective alternative. Mini and mainframe computers tend to have very high costs but, on the other hand, are capable of providing better processing speed, bigger storage capacity, multi-user and multi-programming environment and can be expanded to accommodate hundreds of simultaneous users.

When evaluating the size of the computer needed by a school, it is important to establish the perceived uses of the computers especially if they are also being considered for administrative purposes.

A mobile computer van may provide a cost effective solution for bringing computer education to students, especially those in remote areas. Currently such a mobile van is under trial in Thailand. Equipped with its own electricity generator, a Vax microcomputer and 32 work stations, all housed in an air-conditioned, dust-controlled environment, the mobile van can be driven from school to school as the occasion arises. The Computer Assisted Instruction mobile van being evaluated in Bangkok is produced by Tegem Systems. It comes with software support and may prove useful in other countries of the region.

Centralized vs decentralized location

Microcomputers or terminals may either be centrally located or distributed to different classrooms or offices. In both cases, the site should be prepared for installation.

Centrally located facilities provide better security and administration, maximum utilization and sharing of resources, easier class management, better student to computer ratio and centralized library of software and manuals.

On the other hand, distributing computers to different classrooms and offices provides better accessibility (assuming the campus is big) and venue for demonstration and usage.

Centralized location necessitates careful scheduling of laboratory time, centralized inventory of supplies and materials as well as centralized control of access.

Site preparation

As soon as a decision has been made on the computers that will be acquired, the identified site or sites for the facilities should be prepared.

Preparation of room layout includes the partitioning of the room, design of tables and chairs, safety and security features, electrical wiring and air-conditioning.

Furniture design. The design of furniture for computer use is an important factor which relates to the following aspects:

* Comfort (ergonomic and anthropometric aspects);
* Safety (power connections and cables);
* Security (prevention against damage and theft); and
* Room layout (for effective use and teaching in various situations: class group, small group, individual work).

While some furniture has been developed and is available commercially, no specific research on furniture design has yet been made for use in schools at various levels of education.

Ergonomic factors relating to computer use also need to be studied and applied when machines are in use for long periods of time by students. The following aspects need to be considered:

* Anthropometrics (height of tables and chairs, height of knees relative to top of desk, and so on);
* Quality of screens (poor resolution or reflection of light can be painful to users' eyes); and
* Sound level control (for certain computing equipment, such as printers, sound proofing may be required).

Safety and security. Safety of users should be a prime consideration. Hanging and exposed wires should be avoided. Outlets should be concealed from children as much as possible.

Computers with several cables and wires hanging from them pose a danger to both students and the computers. Not only would this provide opportunity for children to play but will also arouse their curiosity which may lead to their exchanging the connections of the wires and cables causing damage to the computers.

Disk drives should be bolted on the table in order to avoid incurring losses in the computer room.

Inventory of cables, computer boards and supplies should also be considered. Secured cabinets should be provided in the computer room for such purposes.

Security may be enhanced by providing a table which will serve as a control point to physical access to the computer. Supervision of the computer room may be placed here.

In a resource sharing environment, a terminal may also be provided for monitoring time usage, controlling logging in and out, or determining unauthorized users.

Electrical wiring. Very often, new outlets will be required for any additional computers acquired. Depending on the number of facilities to be acquired, new power connection may also be required. The actual power requirements may be obtained from the suppliers. It is advisable to consider allowance for this depending on the expansion plan that is being perceived for the computer room.

For minis and mainframe computers, terminal (communication) lines are also needed.

Electrical supply for the computer should not come from the same outlets used for air-conditioners in order not to add more fluctuations to the voltage entering the computers. It is also advisable to use voltage regulators or power conditioners if the power supply in the location being considered is unstable. Automatic switches can also minimize problems due to voltage fluctuations.

Raised flooring can also be used in order to conceal wires and cables. However, the cost of raised flooring can be high.

Environment control. Another important consideration when choosing a computer site is its environment. The site chosen should not have leaking roofs, should not be subject to flooding and not be exposed to dust and pests.

Humidity can be controlled by dehumidifiers. There should be some form of dust control, while heat can be controlled by air-conditioners or air coolers.

Pests can be avoided by having pest control carried out on the site prior to installation. Rats and cockroaches are very common types of pests. A clean room is necessary so as to avoid future invasion of pests and to avoid fire.

Very often, site preparation is a substantial cost of computer acquisition. Taking into account air-conditioning, securing the room against dust, pests, electrical wiring and voltage regulators, the cost of the site might even be higher than the computers themselves. Therefore, when calculating costs, this factor should not be neglected.

Schools may be unable to raise the funds envisaged above. Computer systems can, however, be selected which do not need strict temperature control, even though they need humidity and dust control. Techniques would then need to be recommended for preparing an existing room to be converted to a computer room at low cost by control of humidity and dust only.

It is necessary to conduct studies on low-cost environment control for computer rooms. There are some interesting experiments on the use of only an exhaust fan, chemicals for humidity control and painting (or covering) for dust control. Some schools are experimenting with specially designed table top enclosures for storing computers at the end of each day.

Flexibility. It is not enough only to look at what is presently required. Future needs should be taken into account so that machines purchased are effective for the tasks required. In this case, flexibility becomes an important feature of the computers that are being evaluated.

Flexibility does not only refer to expansion capability but also to the capability of linking up with other systems, peripherals, video machines, and so on. Thus, features should which provide machine flexibility must be evaluated properly.

Maintenance

Even when a model of computer with a good reliability record has been chosen, there is no guarantee that it will not break down.

Maintenance is a continuing operation for all computers. There are different alternatives for maintaining the computer facilities of the school. One option is for the school to develop its own capability to maintain its own facilities. This implies that the school has people who are knowledgeable about this and could be trained for the specific brands and models acquired by the school. Another implication is the availability of spare parts to undertake in-house maintenance.

The second option is to sign up a maintenance contract with the suppliers. Maintenance contracts differ according to the speed by which service may be provided and the frequency by which preventive maintenance will be given.

A third option is to have an on-call basis contract in which case, the service company is called only when a unit breaks down.

The maintenance option which a school may get depends on its capability to pay for such maintenance and the service level it wishes to provide for its users. If extra facilities are available (as in the case of micros), it is cheapest to choose the third option.

Adapting to local requirements

The ability to adapt computers to suit local requirements is necessary. Usually, local computer suppliers provide locally adapted hardware and software.

In addition to this, the buyer should determine if the supplier will continue to be in business so that they can be assured of support that may be required in the case of any revision made by the supplier.

The school should also look into the details of the adaptation in order to be assured of the necessary support from in-house resources in case the supplier goes out of business.

Laboratory room management

In a centralized location of computer facilities, some care must be taken to ensure proper management and control in the usage of the facilities.

Laboratory usage scheduling is an important consideration in order to maximize the utilization of machines. Laboratory scheduling has to synchronize with the schedule of lectures, workshops and other teaching activities.

In a situation where a teacher is present to supervise the actual use of computers by students, control is simple. On the other hand, when a computer laboratory is open to students of any class, some form of co-ordination and supervision will be necessary.

Usually, computer laboratory assistants are helpful in allocating a specific terminal or microcomputer to each user. They can also control the allocated time a user may have.

Another function of the laboratory assistant is the collection of data and statistics on the types of users, total use per type of user, and statistics on computer malfunction in order to identify units which are starting to show wear and tear.

Computer laboratory assistants can also provide a control point for the sharing of resources such as software and manuals, printers, hard disk, diskettes, and paper.

Graphics and other special features

There is a wide variety of applications of graphics packages. For CAI and CBL, the application is endless. When evaluating these applications, it is necessary to look at the specific details which would provide the needed graphics features. The number of pixels available (a series of tiny elements of single bits) should be evaluated in order to determine the level of detail of the pictures that could be generated.

Evaluation should also include whether there is upper and lower case, high resolution or low resolution, for more vivid illustration.

Technological development is very rapid with the result that there are more and more features becoming available on computers for use in education. Some of these features include speech and sound effects, plotters, mouse input, video connection, multiple screens for one CPU, large screen, portable equipment such as those which are of the size of an attache case, local area network capability, large disk capacity, colour printers, and touch screen.

Insurance

Insurance for the equipment, facilities and data is an important consideration. While it is common for schools to insure their physical facilities, it is not so obvious that software and data should also be insured.

Checklist for hardware

The following checklist may prove useful in highlighting major considerations in hardware selection:

* Are the components in the proposed system readily available and do they represent current technology?
* Is it easy to upgrade the system from an initial number of work stations to the system maximum without having to purchase major components (e.g. new CPU, increased memory)?
* Is a standard operating system used allowing an exchange of developed software with other institutions?
* Does the proposed system include software development tools and are these easy to use?
* Is maintenance and the supply of spare parts readily available and are they reliable?

In addition to the above questions, factors to consider more specifically in choosing microcomputers for schools include:

* keyboard - some keyboards differ from the standard typewriter, and this will clearly be important in most school applications, especially word processing in business and commercial studies.
* memory - certain applications, such as word processing and Logo, require a minimum memory to run.

- colour - this is not available for all microcomputers; colour is essential for many simulations and for graphics and design.
- language availability - while BASIC comes with most microcomputers, Logo and Pascal are options which are not available for all microcomputers.
- screen display - this refers to the size of the screen and upper case/lower case capability, which is important for word processing and in reading and language applications.
- auxiliary storage - an efficient disk drive is required for mass storage and for rapid retrieval in data base applications and much word processing.

5. COMPUTING ACROSS THE CURRICULUM

CHAPTER OVERVIEW

The chapter commences by showing the interrelationships of computers, students and the curriculum. The major part of the chapter is devoted to a consideration of software and courseware. Teachers need to be familiar with software if they are to incorporate computers as tools across the curriculum.

The educational uses of computers basically revolve around learning about computers, and learning with, from and through computers. The different uses of computers involved within each of these two groupings are discussed. Although there is overlap, the distinction is a useful one and there is further discussion of these major educational uses of computers in the final chapter.

Often encountered acronyms like CAI, CBL, CAL and CML are explained. There is also an initial description of knowledge-based systems, or expert systems, which will be increasingly important in educational computing in the future.

As computer education programmes develop within countries, it is likely that schools will move from an emphasis on computer awareness to an emphasis on computer literacy. Some commonly included objectives of computer literacy are enumerated.

Besides using computers for learning and teaching, computers are useful management tools in school administration and in many of the tasks of teaching. Specially developed courseware for pre-service and in-service education of teachers is described.

The availability of software is often limited by a number of factors. These include compatibility, portability, machine dependence, language barriers, cultural bias and network difficulties. The problems of compatibility and portability are amenable to solution, and there is some discussion of recommended courses of action, and of other solutions which are not considered advisable.

Software development is an urgent need and the possibilities of emergent software industries within countries of the region ought not to be neglected. Program shells are described within which teachers may insert content suitable to the needs of their students. To use such shells requires little programming knowledge on the part of teachers. Teachers will, however, need assistance in locating program shells and in learning how to use them.

The chapter closes with some description of different modes of disseminating information about software. These may include the establishment of support centres or school clusters, the conducting of seminars and workshops, and the establishment of national repositories.

Introduction

Information technology, the new technologies, computer-based technologies, are all various terms used to refer to the converging of computers and telecommunications.
Among the technologies involved are:

computers (mainframe, minicomputers and microcomputers)

telephones and electronic message systems

television and video

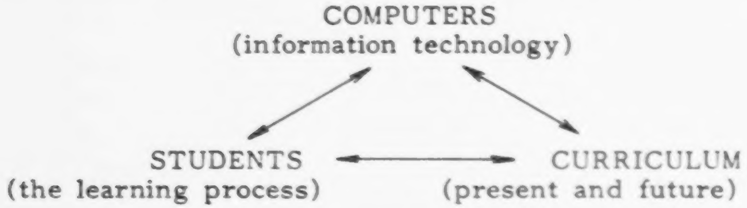
satellite communications

video disk

videotex

A common element in all these technologies is the written or spoken word and so information technology "involves every subject across the school curriculum" (Wellington 1985). Computer education thus involves the interaction of computers, students and the curriculum.

Figure 1. Computers in Education (after Wellington 1985)



Teachers, software and courseware

The current period is not unlike the time following Gutenberg: just as educators then had to experiment with the new media, so teachers in the decade ahead will need to explore if, and how, this versatile tool - the microcomputer - can contribute to learning in the classroom.

It will be necessary for teachers to adopt a dual focus. On the one hand, teachers must first themselves be familiar and at ease with computers. At the same time, they must acquaint themselves with the newer learning materials (software and courseware) becoming available to learners. Only from a position of knowledge can teachers evaluate how the new technology may be integrated into their regular teaching.

The terms software and courseware should first be defined. A useful distinction, to begin with, between hardware and software is the following:

> The contents of a telephone directory may change and in this respect might be termed 'soft'. The telephone, by contrast, is a fairly fixed piece of machinery and thus may be thought of as 'hard'. This distinction applies also to computer programs (as it does equally to TV sets and TV programmes). The machinery is the hardware and the information that allows the hardware to function is the software (Anderson 1985 : 65).

Software, then, is the term to refer to the computer programs or sets of instructions that direct and control the computer. Software usually comes in the form of a flexible disk, called a floppy disk or just floppy, though it may also be on a cassette tape. When computer software is accompanied by teaching materials, perhaps student worksheets, manuals or audio-visual materials, the term used to refer to the curriculum package is courseware.

As is now recognized, if microcomputers are to be useful tools in the classroom, the selection of software and courseware, and the dissemination of these to teachers, are all important. The remaining part of this chapter deals more generally with applications of computers in schools, with questions of availability, compatibility and portability of software, and with information exchange.

Learning about computers

The uses of computers in schools may conveniently be divided into learning about computers and learning with, from or through computers. In view of the enormous impact that computers are having on many aspects of daily life, it is hardly surprising that computers themselves should be considered an object of study in educational institutions. Three different aspects may be distinguished in learning about computers:

a) Computer awareness

- described by one writer as "a national asset".
- it seems likely that as a society's general awareness of computers rises, the need for specific computer awareness courses will decrease.

b) Computer studies

- may include among other things programming of computers, computer architecture and design.

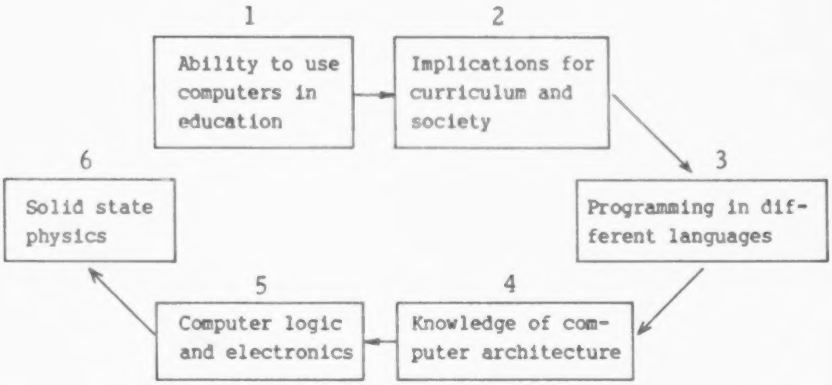
c) Computer electronics

- often included as part of an introduction to electronics or digital electronics.
- can include the study of integrated circuits, flip flops, counters, clocks and logic gates.

Knowledge of computers may be thought of as a continuum, ranging from skills and awareness of computers as learning and educational tools at one end of the continuum, through to programming in higher and lower level languages, and to solid-state physics at the other end of the continuum (Figure 2.).

It is not necessary for all students (or teachers) to be familiar with all the levels of knowledge depicted in Figure 2. It is likely that the first two categories (1 and 2) will be good for all students; some students may go on to categories 3 and 4; and a few students (thinking of the full range of students from primary through to tertiary) will go on to categories (5 and 6).

Figure 2. Continuum of Computer Knowledge


1
Ability to use computers in education
2
Implications for curriculum and society
3
Programming in different languages
4
Knowledge of computer architecture
5
Computer logic and electronics
6
Solid state physics

Learning with, from and through computers

The terminology concerning computers as a learning medium varies widely and there are no universally agreed-upon definitions. Among those frequently encountered are:

a) Computer Assisted Instruction (CAI)

In this mode the computer acts as tutor teaching new skills or concepts or providing practice for learners. Software in this mode is often referred to as:

drill and practice; and
tutorials

b) Computer Based Learning (CBL) or Computer Assisted Learning (CAL)

Various categories of software in this mode include:

simulations and modelling,
instructional games,
problem solving,
information handling,
demonstrations.

While such learning is sometimes thought of as enriched learning, it frequently includes completely new kinds of learning.

c) The Computer as a General Purpose Tool

As in business, commerce and industry, the computer may function as a general purpose tool. These functions are as:

a tool for calculating and statistical analysis,
a tool for writing,
a tool for drawing,
a tool for playing or composing music, and
a tool for design.

d) Computer Managed Learning (CML)

In this mode the computer serves as a tool to help in the management of student learning. Its uses include:

test scoring, managing of student records, and text analysis.

The above terms or expressions are quite common. Less common, but likely to emerge more prominently in the near future as a result of developments in artificial intelligence (AI) is the following:

e) Knowledge-based systems

Knowledge-based systems, commonly referred to as expert systems, are computer programs that enable computers to reason within fairly restricted domains. There are two main components of knowledge-based systems. First, there is the knowledge base, which consists of the known facts about a particular subject area (perhaps the factors contributing to heart disease or facts allowing the identification of parrots). Second, there is an inference engine, which comprises a set of procedures or rules relating to the knowledge base.

A concrete example may clarify the nature of knowledge-based systems. Suppose there is a knowledge base concerning the danger of bush fires. Such a knowledge base contains facts about temperature, wind direction, rainfall and vegetation growth. Using the inference engine, the knowledge base may be interrogated to identify high-risk days. For instance, if "temperature is greater than 40°C", and if "winds are from the north", and if, further, "vegetation growth is above average", then "the danger of fire is extremely high".

A fuller description of expert systems is contained in the Glossary of Terms in the Appendix.

Computer literacy

The term computer literacy covers aspects both of learning about computers and of learning with, from and through computers. It involves consideration of the application of computers in educational settings and in society at large, as well as consideration of the implications for education and for society.

Commonly included among the objectives of computer literacy are the following:

a) An awareness of information technology and how it affects day-to-day living;

b) An understanding of man/machine interaction so that students may have the confidence to communicate and use computers in a variety of ways;

c) An understanding of common computer systems and associated terminology so that students feel 'at home' with them;

d) An introduction to the importance of information so that students may appreciate the full potential of computers as tools in analyzing decision making processes; and

e) An understanding of when computers may be used for problem solving purposes.

The notion of computer literacy has ramifications for much of the work of Unesco, particularly its work on the universalization of primary education. This is because changing methods of storing information now mean that computer literacy becomes a fundamental component of literacy itself. As already noted, the period that the world is moving into with the advent of information technologies, is not unlike the time following the introduction of the printing press 500 years ago. The quantity of information becoming available on the new media requires an educated community.

Computer literacy implies, then, being familiar and at ease with computers generally in the same way that literacy implies being familiar with books. This is one of the major justifications for introducing computers in schools.

Computers for management

There are many ways in which computers may be used for management, for this is their major use in commerce and industry. Examples of software applications include word processing, data base management systems, and information retrieval. These same applications are also being used in school and education system administration. There are other more specific applications packages that have been produced for many of the routine tasks encountered in daily teaching.

To consider but one example of how computers might assist teachers, a series of programs produced at an Australian University (Baumgart, Low and Riley 1982) allows the computer to function as a teacher's tool to analyse students' tests. Such programs could find ready application in most teaching situations. The whole package, comprising sets of slides, computer programs and manuals, was designed as a kit of materials for pre-service and in-service education of teachers. This kit, to be described in greater detail in the next chapter, is an example of courseware.

Availability of software

The amount of software available is wide and increasing rapidly. It ranges across many models of computers, across subject boundaries and national and regional languages, and includes commercially and non-commercially produced materials. Currently, software is being developed by software publishers, educational ministries, computer user groups, universities, school teachers, even parents.

But while the total range of software might be considerable, the amount available in practice is often severely limited. Limiting factors include the following:

Compatibility - programs written for one brand of computer (e.g. IBM) will not run on another (say, Apple).

Portability - often programs written for one model of computer will not run on newer models of the same computer.

Machine specifications - sometimes programs written for one model of computer will not run on the same computer in another country because of differing machine specifications (e.g. different disk drives or varying video signals).

Language barriers - many programs in, say, English will not be suitable for, say, Thai or Japanese speakers because of language barriers.

Cultural bias - cultural bias may preclude the use of some programs even where there are no language barriers or where programs have been adapted.

Network difficulties - programs written for standalone computer systems will often not run on local area networks (i.e. where machines are linked together to share disk drives and printers) and, even if modified, may thereby infringe copyright.

There is an urgent need to build up knowledge among users about sources of suitable software, knowledge of how to adapt software for particular cultural conditions, and to establish mechanisms which provide improved access to suitable software.

Compatibility and portability

Two of the problems noted above, compatibility and portability, deserve special mention. Lack of standards in many aspects, from peripherals to computer languages, has hampered even the demonstration of software, let alone the exchange of software between schools, both within and across countries. It is an area where it would be worthwhile to initiate research and development since it vitally affects educational software production.

One solution to the problem might seem to be to standardize on a particular microcomputer. However, since the requirements of computers for schools are large and therefore can serve as a boost to an indigenous software industry, it is not considered advisable to commit a country's programme in computer education to a particular computer system. As well, technological developments are making 16-bit systems comparable in cost to 8-bit systems. Therefore, to standardize on, say, a particular 8-bit system is to close off options on new developments.

Since the backbone of an effective computer education programme is the availability of educational software, tailored to the local context, software developers want to have machine independence to offset changes in hardware. It is thus necessary to develop methodologies for making a software package adaptable to a variety of hardware with little or no effort. This same problem has also confronted business users of personal computers. The results of research and development do exist among various research groups to tackle this problem through standardization (though not of hardware) and software development techniques.

Defining an operating system and language environment (say MDOS and HBASIC), which could be met by all hardware developers, has been considered the best approach. It would be useful for current thinking in this all important area of software portability, if such information was disseminated to all countries.

Software development

If teachers are to accept the new technologies, then the software that is available needs to be educationally suitable and teachers need to feel they 'own' it in some way. For these reasons it is important that teachers are themselves involved, if not in the actual programming of software, at least in the design and formative stages.

A useful distinction is sometimes made between programs with relatively fixed content and programs with content that may be varied. The latter are described as "content free" and consist of "shells" within which teachers may insert their own content to suit the needs and ability levels of their students. The use of software of this kind needs to be encouraged and teachers need to develop skills to modify content for their purposes. Besides being educationally sound, such modifications help to enhance teachers' feelings of ownership of the curriculum materials.

Modification of program shells to insert specific content material does not require advanced programming skills. It may require some programming knowledge, but more generally what is needed is programming-like abilities. Teachers need help in acquiring these skills.

Software dissemination and information exchange

Despite the difficulties of language and cultural differences between countries, as well as problems of portability across different microcomputers, there is nevertheless seen to be value in co-ordinating and disseminating information about software production among the countries in the region. The most important ingredient in any computer program is, after all, the idea behind the program. Holding meetings of experts in software design and production is one possibility; an information exchange of the clearinghouse variety is another.

Mention was made above to program shells, within which teachers may insert content of their choice, to meet the needs of their students. There are a number of such program shells available. Teachers need information about these and about other general purpose software. This may involve the establishment of support centres, or school clusters, or by conducting regular seminars and workshops.

Teachers who get excited about using computers in their teaching want to know about relevant efforts elsewhere. Currently, the "grape-vine" is the approach used and this acts as a deterrent for teachers. It is important for teachers to be able to contact national repositories for information, be it software, literature, or experiences about certain equipment. Every worthwhile computing experience must be disseminated within each country. Perhaps the school library can be extended to provide local services and it can in turn contact a national repository for particular requests that it cannot satisfy from its own collection.

Organizing a software repository needs special approaches, as compared with literature collections. It will be necessary to develop guidelines for organizing national repositories.

6. TEACHER EDUCATION AND CURRICULUM DEVELOPMENT

CHAPTER OVERVIEW

Hardware, software, teacher education and curriculum development are the cornerstones of successful computer education programmes. Two of these cornerstones, teacher education and curriculum development, are the concern of this chapter.

The role of teachers is crucial for any curriculum change. The successful implementation of a national computer education programme will depend vitally on the adequacy of teachers' preparation to incorporate this new tool - the computer - in their teaching. Insofar as computer literacy and computer studies is part of a country's education policy with links to national policies on economic development, teacher education in the use of computers assumes an important dimension.

There are two main thrusts for teacher education. One is at the pre-service level. It will be necessary for all new teachers to be familiar with using computers in their teaching. As well, there is a need for some teachers to be prepared to teach computer studies at the senior levels in high schools.

The second thrust must be the continued professional development of all current teachers. A range of target groups for in-service education programmes and the kinds of topics which might be included in these programmes is described.

There is discussion, too, of the knowledge and skills required of teachers involved in teaching computer literacy courses in schools, and the somewhat different knowledge and skills required of teachers who will use computer based learning in their classrooms.

Because of the magnitude of the task of teacher education in the uses of computers, teachers as professionals must accept some responsibility for their own continued professional development. Some self-learning systems are noted, including the use of specially prepared software to teach about aspects of computers.

Whether computer programming should be a skill required of teachers is a controversial question. Teachers may need to know something of Logo and PILOT, the one a programming language for learning and the other an authoring language. Teachers will also need to be familiar with general purpose programs, such as word processors and data base applications, and these require programming-like abilities.

The chapter closes with some discussion of curriculum requirements at both the school level and the post-secondary stage or tertiary level of education. Three main categories of computer use can be identified at both these levels: computer literacy, computer based learning and computer studies.

Finally, there is consideration of the needs of non-formal education which involves bringing information about computers to the general public. There are several possibilities here. Television and the other mass media are suggested as most promising.

Introduction

Previous chapters have dealt with computer hardware and the availability of educational software, as key considerations in implementing a national policy of computer education. This chapter deals with teacher education and curriculum development. These four areas - hardware, software, teacher education and curriculum development - are the cornerstones of successful computer education programmes. It is not true to say that any one is more important than any other. Neglect of any one area is to reduce the chances of implementing a successful programme.

National policy on teacher education

Any change in education relies heavily on changes in teachers' attitudes, knowledge and behaviour. The implementation of a programme on computer literacy and computer studies is no exception. The proper preparation of teachers is critical to the introduction of computers in schools. The need to equip teachers to undertake these new teaching tasks must be appreciated not only by teachers in schools but also by top level administrators as a fundamental part of a national computer education programme.

If necessary, appreciation seminars and other opportunities should be provided for those in positions of responsibility for implementing computer education programmes in each of the Member States before embarking on any national programme. It needs to be appreciated that the introduction of computers in schools is closely linked to the purposes of schools. In some countries education may need to be reformed in order to adjust to the coming information society; in others the protection of domestic industries involved in microcomputer production is of prime importance; while in yet other countries unemployment problems need to be tackled and the work-force needs to be prepared to meet the demands of jobs opened up by the new technologies. Thus the introduction of computer literacy and computer studies is part of a country's education policy, which in turn is part of a national policy on development.

Teacher education in computer education, then, must be recognized as part of the national policy of economic development. At another level, to neglect teachers and principals in schools, is to doom any computer education programme.

Pre-service teacher education programmes

The education of new teachers to enter the teaching field is in the nature of a long-term investment. The length of pre-service teacher education programmes usually varies, from a one year programme to a four-year undergraduate programme. In the case of the four-year programme, students commencing training in 1986 (assuming teacher education programmes already reflect the new technologies) would not begin teaching until 1990. The impact of graduates from one-year programmes, of course, would be felt sooner. Clearly it is important to modify pre-service teacher education programmes quickly so that at least all new teachers entering the profession will feel at ease with computers.

Essentially, changes need to be implemented in two types of teacher education programmes. The first is in the programmes of all would-be teachers. The curricular content of these programmes needs to be revised to include topics on computer literacy, computer assisted instruction, and computer based learning (what it is, how and when to use computers). There may be a place for some computer programming (discussed further below). More important than the inclusion of new topics within teacher education programmes is the use of the computer as a tool across all topics. This means, naturally, that teacher educators themselves need to be familiar and at ease with computers.

The second type of teacher education programme is for those teachers who are going to teach computer studies or computer science at the senior secondary level. Such teachers will desirably be graduates in computer science or graduates with a minor in computer science. Most universities now offer undergraduate degrees, and some post-graduate degrees also, in computer science. The problem is to attract such graduates to a career in teaching, for the monetary rewards in industry usually far surpass those in teaching.

In both types of programme, computer education should be closely related to subject matter teaching, though this may be difficult with the second type. Failure to attempt some kind of integration can lead to a loss of motivation in some or others who become addicted to computers.

In-service teacher education programmes

The continued professional development of teachers already in the field is an enormous one at any time. Where a particular innovation such as computer education impacts on all levels of schooling and cuts across all subject boundaries, the size of the task is almost too daunting. Nevertheless, it must be re-emphasized that the motivation and morale of teachers is crucial to any reform. Hasty introduction of computers in schools, without any grass-roots involvement of teachers, will jeopardize the whole programme.

One way to make the task more manageable is to identify the separate target groups for in-service programmes. Each group is likely to require courses of different content and varying length. Some of the groups that might be identified are:

- Principals of schools
- General subject teachers
- Specialist teachers (geography, science, history, and so on)
- Teacher-librarians
- Computer studies teachers
- Teachers of computer awareness or computer

literacy courses
- Advisory teachers.

The type of course offered and the approaches taken can cover the whole spectrum of short, medium and long courses, intensive courses, hands-on experience, regional conferences, workshops within a school, school cluster meetings, intensive training of key teachers within a school, and so on.

The kinds of topics that might be featured in in-service teacher education courses include a wide variety:

introduction to microcomputers

computers in society

word processing

Logo

software evaluation

social/educational implications of computers

instructional uses of computers

computer assisted instruction

authoring languages

design of educational software

the use of program shells (see Chapter 5)

management of school computing resources

the use of data base programs

computers in specific subjects (e.g. history, art)

Mention was made in Chapter 5 of a kit of materials comprising sets of slides, computer programs and manuals for use in in-service (and pre-service) teacher education programmes. The kit was produced as part of a Student Assessment Project (Baumgart, Low and Riley

1982) at Macquarie University in Sydney and the programs run on the Apple microcomputer.

One of the program modules produces test analysis statistics for classroom tests. The program may be used for both norm-referenced and criterion referenced tests. Tests are scored, and percentages and a histogram of the distribution of marks displayed. Statistics which can be computed include mean test score, standard deviation, reliability coefficient and standard error of measurement. Two other program modules allow the teacher in interactive mode, to enter student data into a file or to add data to an existing file.

Another program module combines marks (tests, projects, and so on) within a subject or across subjects. Yet another program module is used to adjust marks so that the mean and the standard deviation are aligned to those of another test. The final program module provides a Rasch item analysis.

Such programs as these, and other similar ones, are useful classroom management tools, not only for analysing class tests but also for providing insights into topics like moderation and scaling. The reason for describing this kit in some detail is that it was especially designed for in-service education of teachers. The accompanying slides, together with the computer programs, can be used by teacher groups with minimum guidance. Insight is provided into the use of computers as a management tool for teachers.

Computer literacy and CBL courses for teachers

In order to conduct any courses for teachers, pre-service or in-service, it is necessary to identify the target audience and understand the skills and knowledge that are appropriate for each audience.

Thus, for teachers of computer literacy programmes, the following knowledge and skills might be considered necessary (based in part on Teaching, Learning and Computers: 1984 Information Kit (Commonwealth Schools Commission 1984):

- Working knowledge of computer awareness/literacy course guidelines.
- Classroom management skills relating to control, use of and equitable access to equipment and its integration into lessons.
- Competence in using hardware and software in both demonstration and small group modes.
- Skills appropriate for teaching social issues arising from use of information technology. These include discussion, social analysis, use of video and other resources for this purpose and setting and marking of essay work.
- Competence to run and assess package software, to handle simple faults (power cords, drives needed or not, printer connection) and care of equipment.
- Knowledge of printed and other resources for teaching computer awareness/literacy courses and of sources for keeping this knowledge up to date.
- Knowledge of suitable software to support the aims of the courses and of sources of new software.
- Skills in selecting suitable software for these courses.
- Ability to identify and use general sources of current information about computing as it relates to computer awareness courses.
- Ability to discuss social issues that relate to use of information technology generally and to educational uses in particular.
- Enough computer programming skills to be able to teach programming at the level indicated by computer awareness/literacy course guidelines.
- Understanding of and ability to implement good programming practices.

* Working knowledge of the use of the computer as an information handling tool.

For teachers who will use computer based learning in their classrooms, by contrast, the following skills and knowledge might be considered appropriate:

* Awareness of the potential of computing in the teaching of the subject; familiarity and understanding of the extent and nature of computer use in the subject area outside schools.
* Minimum knowledge (level similar to that suggested for Computer Awareness Teachers) of equipment operation, maintenance and care.
* Working knowledge of available software, sources of software, and sources of information to keep this knowledge up to date.
* Software selection skills.
* Classroom organization skills, integration of equipment use into lessons; use of demonstration and small group techniques.
* Awareness of changes in curriculum and shifts in emphasis due to new technologies.
* Ability to discuss social impact of information technology on the subject area.

Where there is already a well-developed programme of in-service activities for teachers within an education system and an expectation that teachers will avail themselves of such professional development, the task of implementing in-service teacher education courses on computer education becomes manageable. Where there is no well developed structure, establishing the requisite climate becomes a prior task.

Self-learning systems for teacher education

One mechanism to alleviate the problems of teacher education is to introduce self-instruction or self-learning systems. These might be packages of course materials for teachers comprising reading materials and illustrations, with accompanying questions and discussion points. Because there are fewer teacher instructors due to financial cutbacks in education, teachers' self-learning efforts to renew their knowledge and improve their professional skills will be an important aspect of in-service education.

Teachers can, however, be assisted in this self-learning by encouraging their efforts. The enthusiasm of one or two teachers on each school staff can be utilized by encouraging them to share their skills with other school staff. It may be possible also to harness community resources by, for example, inviting members of computer societies to address staff meetings and to exhibit new equipment or software.

The computer itself can be effectively used to teach inexperienced users about the keyboard, about programming languages and educational applications. Software is available now for most of the microcomputers used in schools to introduce the major features of computers. There is obviously a need for translation of this software into national languages.

Mention should be made also of the use of video and television as a teaching medium. The Computer Literacy Project in Britain is described in Chapter 3. The two ten-part television series "The Computer Programme" and "Making the Most of the Micro" have already been used by countries in the region for raising teachers' awareness levels in computer education. These programmes are available from the British Broadcasting Corporation (BBC) in several video formats. For a modest investment, these programmes could be used, where appropriate, with teacher groups around a country.

Programming for teachers

Whether teachers should be taught to program is a question about which there is much debate. One view is that the usual kinds of courses where teachers are taught the rudiments of programming are not sufficient to enable teachers to apply the skills and knowledge learned to any significant educational problem. Besides, the argument continues, the teachers' major task is to teach, not to program. An opposite view is that teachers ought at least to keep up with the skills of the average 9 and 10-year-old, and certainly many children of this age know something of elementary programming.

What is important for teachers to know is how to save files, for instance, in word processing for there would be nothing quite so damaging as to be unable to help students save their work when they use a word processor for creative writing. Teachers will also want to know how to use software packages.

Word processing, spreadsheet and data base programs are relatively easy to use with practice, and teachers readily see applications for such general purpose tools in their teaching. Logo is a programming language that is widely used in schools as a language for learning, and teachers will probably require an acquaintance with this programming language at least.

Authoring languages and authoring systems are rather specialized programming languages designed specifically to assist teachers to develop CAI materials. It may not be unreasonable to expect teachers in the future to be familiar with languages like PILOT (there are many versions for microcomputers) so that they can develop short programs appropriate to their teaching.

It is desirable for teachers to relate their skills and knowledge of computing directly to their current teaching. In the case of science and mathematics teachers, it may be that generalized programming packages such as word processors, and to a lesser extent spreadsheet programs, are less applicable to their teaching. Such teachers usually wish to acquire high-level programming skills in, say, BASIC or Pascal, so that they might construct programs suitable to their subject areas. Therefore, the content of teacher education courses, and the methods used, must vary according to the interests and specializations of the teachers concerned.

Curriculum development

When considering curriculum development in computer education, it is necessary, first, to identify the different levels for which computer education is to be provided. Within formal educationthere are two broad categories - school (kindergarten to year 10 or 12) and university, whereas non-formal education embraces all non-institutionalized learning.

Second, within the different levels, one must identify the different types of computer education which may be provided such as, for instance, computer literacy, computer based learning, and computer studies. The need for such categorization becomes clearer when the strategies and processes by which each may be delivered is considered. Furthermore, each type requires teachers with different skills and knowledge, thus implying different types of teacher education programmes for their proper implementation.

The remaining part of the chapter considers computer education programmes for schools and for the tertiary level, together with the general needs of non-formal education.

Computer education programmes for schools

Within the school-age range of education from kindergarten to the senior levels of secondary or high school, three distinct types of computer education may be identified: computer literacy, computer based learning and computer studies.

Computer literacy

Within this category is included the application and implications of computers in society. The depth of discussion will depend on the level of maturity of students. Usually, included also is a study of:

a) computer concepts (which may be taught without any computer facilities);

b) software packages such as word processors, data base management systems, and spreadsheets; and

c) some form of programming using any of the widely available languages like BASIC, Logo or PILOT.

The objectives for including these areas within computer literacy were enumerated in the previous chapter. These include being aware of information technology, understanding man/machine interactions and common computer technology, realizing the potential of computers and understanding when and how computers may be used and for what.

Computer based learning

Using computers for teaching and learning may be more effective than other methods, largely because the computer can supplement other teaching and enrich learning. A computer based approach to learning can be achieved in different ways but, whatever the methods used, learning should be centred on the topics or areas being taught, and not on the tool - the computer.

Computers may be used to supplement other teaching methods by providing drill and practice in different subject areas. The computer is a very patient tutor. More importantly, teachers are thus freed to be creative and to concentrate on teaching and providing individual attention.

As well as this tutor role, computers can be integrated with other teaching activities, inside and outside the classroom, to provide more enriched learning. For instance, the use of data base packages within particular subjects like economics, history or geography provides an opportunity for students to appreciate historical information, analyze historical events and deduce conclusions. Another example is word processing where students, who are learning the processes of writing, are freed from the constraints of providing a neat copy.

In these types of learning, computers provide opportunities for students to acquire new knowledge and skills through simulation, information handling, problem solving, data analysis, graphics and games. In this way computers provide students with new tools and techniques, and so complement or extend existing teaching methods.

Computer studies

While some students may be satisfied with knowing what computers are and how they affect their day-to-day living, there are other students who prefer to explore further and understand why and how computers work. In this type of computer education, the following levels of understanding computer 'internals' may be identified:

a) Programming;
b) Computer organization;
c) Systems analysis and design;
d) Information systems; and
e) Computer architecture.

The objectives for providing studies about computers are to:

- develop good programming style, to promote capability to analyze problems, and develop computer solutions for them;
- understand the different components and functions of typical computer systems and how these relate within their environment;
- develop knowledge of information systems, applications and development of techniques;

- make students capable of using software packages relevant to information handling; and
- enable students to identify present and potential uses of information technology.

Courses in computer studies may be introduced at different levels and have varying emphases, according to the purposes of schools or policies on computer education. The courses may be provided in technical, commercial or general secondary or high schools.

Computer education programmes at the tertiary level

Another important component of formal education is the tertiary level, sometimes also called university or college level education. Computer education at this level may be categorized in a similar manner to that adopted at the school level. However, there is a need to redefine the rationale and the content of each category.

Computer literacy

Since computer literacy programmes at the elementary and secondary levels are not yet universally implemented, tertiary level education should provide programmes similar in content to those described in the previous section. This transitory nature of computer literacy education at the tertiary level implies that the content of computer literacy programmes will need to be modified in the future. This transition period may take several years for most developing countries.

As "Computers in Society" type courses are provided at the tertiary level, the emphasis should be in terms of computer awareness and the social implications of computers. Special attention should be given to how individuals are affected by information technology and how they may utilize this technology.

Computer based learning

Computer use as a tool across the teaching and learning of different subject areas is emphasized in computer based learning. Curricular revision is perceived to be necessary in order to update the teaching and learning of different degree programmes using computers as one of the tools.

Some ways by which computer based learning may be undertaken at the tertiary level are through the:

a) provision of drill and practice sets of exercises for skill development;

b) provision of computers for problem solving in subjects like mathematics and accounting;

c) provision of tutorials for individualized instruction;

d) development and analysis of models and simulation for different subject areas such as management and decision-making, planning, physics and economics; and

e) development, implementation and use of data banks in order to enable students to realize the implications of information technology in their chosen fields.

Computer studies

Computer studies in Computer Science courses and in Engineering may be offered at the bachelors, masters and doctoral levels. Such degree programmes may place emphasis on both hardware and software.

The objective for offering such degree programmes is mainly to develop computer specialists who will be capable of analyzing, designing, implementing, monitoring and evaluating components or whole computer systems or information systems.

At the same time, computer science information systems may be offered as a component of studies in other disciplines. As such, the degree programmes remain in whatever professional area is being offered, with the main difference being the inclusion of computer or computer related subjects.

The purpose for including such courses in the curricular offerings of these degree programmes is to integrate computers and their use in the professional areas.

Non-formal education

Besides the components of formal education, school and university, discussed above, there is a need to introduce the public at large to the uses of computers. The type of computer education that is appropriate here is computer literacy. Among the different groups within the general public that can be identified might be included the handicapped, the unemployed and those working at home.

Computer literacy for the general public may be provided through a range of different types of computer related programmes: seminars, workshops, exhibitions, mass media (radio, television and newspapers), computing activity centres, clubs and societies and libraries.

Mention has been made in this chapter of the power of television to reach teachers. Television, and the mass media generally, can prove an effective means of reaching the general public too. However, it must be for each country to encourage activities, in whatever way, that are judged most appropriate.

7. KEY CONSIDERATIONS FOR EDUCATORS

CHAPTER OVERVIEW

This final chapter draws together the main themes running through this publication. At the outset, it is important for education policy makers to judge the appropriateness of the new technologies for education. A list of 11 criteria is presented which may prove useful as a framework for evaluating the introduction of microcomputers into schools. While there seems little doubt that computers will play an important part in the education of all in the future, some criteria act as pointers for policy. For example, that the technology should foster indigenous resources and skills is a constant theme of preceding chapters.

The dual meanings of computer education, one of teaching and learning about computers, and the other of teaching and learning with, from or through computers, is an important distinction for policy. It governs the allocations of resources since it affects how computers are used, at which levels computers are used, and the preparation of teachers.

The major barriers to implementing computer education programmes are hardware, software, teacher education and support services. Adequate resources need to be allocated to each of these areas if nationwide computer education programmes are going to have a chance to succeed. These areas form the substance of previous chapters.

Perhaps a further major barrier is any reluctance by teachers to use computers. Computers are different from any other educational innovation in that the perceived need to introduce computers into schools has come, not from within education, but from outside. To reject the use of computers in schools is to run the serious risk of putting schools out of step with what is happening in society.

The major part of the chapter is devoted to an initial consideration of the development of a national policy on computer education. There are three key questions to ask: Who are the learners? What are they to learn? Why must they learn? The answers to these questions do not of themselves provide a statement of policy. Nevertheless, it is through answering such questions, taking into account the particular conditions and factors operating within a country, that policies on computer education are arrived at.

The chapter closes with an examination of the new demands being made on literacy teaching. Developments in communications and computers have lead to vastly increased storehouses of information. Computer literacy is the key to these storehouses. This is a major justification for developing programmes in computer education.

Introduction

In this final chapter there is an attempt to tie together the various threads that run through this publication. The countries in the Asia and Pacific region are at different points along the road to becoming computer literate societies. Whereas some countries are at the very beginning stages and are even now considering what steps to take to introduce computers into education, other countries have taken the initial step and are considering the further development of the uses of computers in education. There is little doubt that computers will play an important part in the formal and non-formal education of all in the future.

Criteria for judging computer-based technologies

One writer (Burns 1981) has listed the following 11 criteria for judging the appropriateness of any technology:

1. The technology must be intelligible to the community as a whole.
2. It must be readily available at a price within the range of most individuals.
3. It must fulfil a socially useful purpose.
4. The tools and processes utilized must be under the maintenance and operational control of the local work-force.
5. It should use indigenous resources and skills.
6. It should create employment.
7. The production and use of the technology should present no health hazards to the personnel concerned.
8. It should be non-pollutant, ecologically sound and where applicable it should recycle materials.
9. It must prevent external cultural domination.

10. It should where possible allow fulfilling, flexible, creative and innovatory use.
11. It should fit into the existing social infrastructure. In short, an appropriate technology is one that is understood by the bulk of the population, uses skills which are readily available, does not adversely affect the environment or community, and which achieves a social objective.

Although Burns was not discussing computer based technologies specifically, it may be useful for each country in the region to consider how appropriate are the new technologies for education when judged against these criteria - even if just to point to potential dangers. As one example, that the technology should foster indigenous resources and skills (Criterion 5) has been stressed in preceding chapters.

Dual meanings of computer education

The term *computer education* in any policy guidelines or curriculum description needs explanation since two rather different meanings may be inferred. Some educational practice tends to place emphasis on the first part of the phrase - the *computer* - and in this case the term becomes not unlike, say, science education or history education, where the computer comprises the teaching/learning content. Other educational practice, by contrast, may place emphasis on the second part of the phrase - *education* - in which case teaching or learning techniques become central, with the computer being used as a tool.

In other words, a distinction needs to be made between teaching and learning *about* computers, on the one hand, and teaching and learning *with*, *from* or *through* computers, on the other. In developing programmes in computer education, it is important to recognize these dual aspects. Chapter 5 describes in greater detail what are the curriculum implications arising from the dual meanings of computer education. It is for each education system to determine where emphases are to be placed at each rung of the educational ladder and what the overall priorities should be.

Major barriers to implementing computer education programmes

There are a number of barriers to implementing a computer education programme successfully across a system or nationwide. While these are discussed separately below, and have had separate chapters devoted to them in this publication, they are interrelated and need to be considered together.

The first barrier relates to hardware. The computers themselves are the most visible signs of a computer education programme and are clearly essential to any programme. It may be possible for students to learn something about computers without access but, for advances to be made and any significant learning to take place, computing equipment is obviously necessary; it is, of course, not possible to learn with, from or through computers without access, to pick up the second meaning of computer education noted above. Any barrier to hardware acquisition is relatively easy to overcome since funding is all that is required.

The second barrier relates to software. Only with software is the hardware able to function at all. A glance at the numerous computer software catalogues available might suggest that barriers to software acquisition are also relatively easy to overcome, simply requiring adequate funds for purchase. Unfortunately, this is not so. Software is machine-specific and requires a particular operating system to run. In view of the lack of standardization it means that the quantity of software available is immediately reduced when considering programs to run on a particular microcomputer. Coupled with the lack of standardization, is the dearth of software in particular national languages and scripts encountered in the region, further confounded by the fact that programs are often either culturally or gender biased. As if these problems were not sufficient, a further problem is that much software may be educationally unsuitable. For instance, much commercially available CAI material runs counter to the philosophy of teaching and learning held by many teachers and the indiscriminate use of these materials in the classroom is considered likely to retard teaching practice. The software barrier is considered by many computer educators to be the Achilles heel of national computer education programmes.

The third barrier relates to teacher education. Without teachers adequately prepared to use computer-based technologies, the best available software and the most up-to-date computing equipment will remain unused. Teachers will continue with teaching practices they have found successful in the past or, if pressured to use technology with which they are unfamiliar, will make token gestures. In either case, the full potential of the new technologies will remain unrealized. Preparing teachers to be at ease with computers and to use computers across the curriculum is a large task. It requires education of new teachers commencing teaching careers as well as the re-education of all those already in the teaching force.

A fourth barrier relates to support services. All machinery will eventually break down or become unreliable. It is necessary to provide adequate maintenance to ensure reliable performance of computers, disk drives, monitors and printers. Similarly, teachers are going to have to be kept up-to-date with information about new software and new ways of using programs in their teaching. Too many promising educational innovations have been abandoned because of lack of continued support or because the enthusiasm of educators has been channelled to some other new innovation.

Teachers' reluctance towards computers

Not all teachers and educational administrators have been persuaded of the need to introduce computers into schools. There may be several contributing reasons. It may be that computers are still relatively new. It may be because some teachers are reluctant to use any technology beyond chalk and talk. Or it may be because many teachers remember similar enthusiasm for programmed learning, for teaching machines, for language laboratories, and other educational technologies. Many of these innovations did not achieve as much as anticipated, especially in developing countries.

This third cause for reluctance, that computer education is just another educational fad, is a source of major concern. It should be noted that a key difference between the current thrust for computers and the enthusiasm for earlier technologies is that most other educational innovations have come from within education: the use of computer technology comes from outside education. Wellington (1985) puts it another way:

> ... computers are fundamentally, qualitatively different from other pieces of technology. Quite simply: computers pervade society (Wellington 1985: viii).

Teachers' reluctance towards computers, then, on the grounds that similar innovations have come and gone before, poses the greatest challenge to educational policy makers. Such a stance runs the risk of putting schools out of step with what is happening in the rest of society, since there is no evidence elsewhere of a retreat from computer technology.

Towards developing policy

It is not sufficient to argue, of course, that because computers are so important to the functioning of any modern society, that computers should therefore feature in the school curriculum. Aeroplanes are similarly important and most countries have national airlines:

this does not mean that the study of aeroplanes should feature in the school curriculum. This highlights the critical distinction made at the beginning of this chapter between teaching and learning about computers, on the one hand, and teaching and learning with, from and through computers, on the other. Computers are different not only from aeroplanes, but from every other technology.

Nevertheless, educators must be prepared to justify introducing computers into schools. There must be some rationale. In attempting to arrive at some kind of rationale, discussion focuses on three critical questions.

Who are the learners?

This question may be answered in varying degrees of specificity according to educational conditions operating. One suggestion is that four groups of learners, for whom knowledge about computers and their use is necessary, may be identified:

a) all students at all levels, kindergarten to university;

b) some students with a special interest in computers but who do not wish to major in computer technology;

c) technician groups in commercial and technical schools; and

d) computer specialists and engineers.

A second suggested grouping of learners, not directly at variance with the above but oriented more towards adult life after schooling and out of school youth, is the following:

a) the general public;

b) computer users; and

c) computer specialists.

In these groupings of learners, the terms ALL, SOME and FEW are used purely as descriptors. They may convey some indication of the numbers involved though this will vary according to a country's needs. Obviously, though, the second group (SOME) and the third group (FEW) are subsets of the first group (ALL).

If the second suggested grouping above is considered reasonable, three groups of learners within the continuum of education may be defined more closely and appropriate curricula developed.

a) ALL learners:
Microelectronics is transforming the work and life styles of all people. The education that we impart today should equip all learners for the telecommunications revolution which is changing the environment of everyone.

b) SOME learners:
Some people will work closely with computers, either using them as tools or working in an environment where they interact and communicate with other skilled computer users. Schools need to provide opportunities for some students to develop interests and skills in information processing.

c) A FEW learners:
There is a need for a few people to be highly trained in the various specialisms of the microelectronics industry. The education system needs to prepare a few students to fill these roles.

What are they to learn?

For the purposes here, a brief answer follows for the three groups identified above.

a) ALL learners:
Computer awareness/literacy/appreciation

includes being familiar generally with telecommunications of which computers are a part, and having a broad understanding of computers and their use. These are goals for all learners.

b) SOME learners:
Computer fluency implies some degree of competency in interacting with computers, not necessarily developing programming skills but rather developing programming-like abilities. The use of some applications software (e.g. accounting and spreadsheet packages) requires a clear understanding of computer input, data processing, and output. For some learners this kind of knowledge of the capabilities of computers is required.

c) A FEW learners:
For a few learners there is a need to be familiar with specialist applications of computers, to be able to design new applications and better means of communicating with computers.

Why should they learn?

Again an answer to this question is sketched briefly for the three groups identified.

a) ALL learners:
It is important that all learners should
- be comfortable about using computers;
- be aware of their potential and limitations;
- be familiar with the range of computer applications in society;
- know the implications of such applications;
- recognize the computer's capabilities for storing and accessing information; and
- be able to cope with the explosion in the amount of information available.

Implicit in these objectives is the real reason why all learners should be familiar with the new technologies. Computers provide new and powerful tools for storing and accessing information. Increasingly, as the world storehouse of information is held in the memory banks of computers, it is imperative that all learners know how to access this storehouse.

b) SOME learners:
The number of computer users will grow with advances in technological development. It is important that those who work in computer environments can communicate effectively with technologists, with programmers and systems analysts. For some people a fuller appreciation of the capabilities of computers is thus necessary in order to distinguish between what are reasonable expectations of whatever may be the current state of technology and what is unreasonable.

c) A FEW learners:
There is a need to produce a better interface between people and computers. This requires software that is designed for the general public and is easier to use. To design and produce such software requires special skills on the part of a few people.

Towards a rationale

The discussion above relating to the major questions:

Who are the learners?
What are they to learn?
Why must they learn?

does not, of itself, provide a full rationale for computer education. Each of the countries in the the region and each education system within the countries must go through the exercise of answering questions such as these for the particular conditions and factors operating within the country. It is through such strategies that policies on computer education may be arrived at.

New demands for literacy

It seems more than likely that, as in previous evolutionary milestones of human communication, the new computer-based technologies will bring about changed definitions of literacy. In the foreword to a recent publication of reports on computers and literacy (Chandler and Marcus 1985), Adams writes:

> The evidence is very clear that the impact of micro-electronics and computing generally will make more rather than fewer demands upon literacy, and that the definition of literacy will have to be extended to include screen reading and writing if it is to be adequate to the needs of those growing up in present-day society (Adams 1985 : x)

Geoffrion and Geoffrion (1985) echo similar sentiments in their account of computerized dynamic books, which the new technologies can be expected to make a reality in the not-too-distant future.

Books will continue to be used; and so will pens and pencils. But the computer will slowly begin to replace certain kinds of books. Already the computer is replacing the telephone directory in certain countries. In schools, drill- and practice-type books can be expected to go. Computers can provide drill and practice now, tailor-made to the needs of individual students, and the computer version is more motivational than the book version. Then we can expect encyclopaedias and manuals of technical information to be available on computer and video disk. Dictionaries and thesauri are other kinds of books that might be expected soon to be available on floppy disk.

The demands on schools to teach reading will remain as they do now, but the kinds of reading skills will need to increase to include efficient reading of screen displays. Reading of computerized screen displays is already a requirement made of increasing numbers in the work force. Public and private information databases like Captain and Viatel require readers to take in information by 'screenfuls'.

Moving backwards and forwards with screen-based texts calls for different literacy skills compared to book reading. Readers need to be more active: they must respond to prompts appearing at the top or bottom of the screen and take some action to advance to the next screen of information or to jump to some other part of the text. Responding to screen prompts therefore becomes a new literacy skill.

However, the major new demand upon literacy is for students to learn how to access the new world storehouses of information. Before the mid-1400s important information was stored on clay tablets or parchment. With the invention of the printing press, books became the repository for recording mankind's experiences. The vastly increased supply of information in the world today, has resulted in new modes of storing the information of mankind on computer media. And just as the major goal of literacy has always been to provide all citizens with the skills to access the accumulated wisdom collected in libraries, so the major goal of literacy will continue but citizens of the future will need to know how to access and retrieve information stored on computers.

Throughout history, literacy has given power to those who have mastered the necessary skills required by society at the particular stage of social and political development reached. Dillon's conclusion, therefore, that "computer literacy will be the new access to power in a high technology and information processing society" (Dillon 1985 : 98), seems inescapable.

Here is the major justification for developing programmes in computer education.

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Appendix

GLOSSARY OF TERMS

Animation

The rapid changing of images on a screen has the same effect as a movie film in that it produces the illusion of continuous motion. Such a facility, referred to as animation, enables one to display a time-varying phenomenon such as progress of a wave or the accelerated growth of an organism. Animation can also be used to illustrate how complicated mechanisms work.

Auxiliary Storage

See Winchester.

CAD (Computer Aided Design)

The use of the computer and special graphics packages to help in drawing and design.

CAI (Computer Assisted Instruction)

CAI is closely related to programmed instruction. It involves use of the computer to direct learners by providing drill and practice activities. It also involves the teaching of new skills, commonly referred to as tutorial.

CBL (Computer Based Learning)

CBL, sometimes also called CAL (Computer Assisted Learning), involves using the computer in such a way that learners take greater responsibility for their learning compared with CAI (Computer Assisted Instruction). The various kinds of activities included under CBL are simulations and modelling, instructional games, problem solving, information handling and demonstrations. Such learning through the computer is seen as enriched learning.

CBT (Computer Based Tutor)

With computer Aided Instruction (CAI) computers are used to create a learning environment allowing students to progress at their individual pace and also to monitor their own progress through quizzes. Thus CAI allows students to be treated as individuals. However, so far it has not been able to provide a real 'one-to-one' interaction that a human tutor provides. Tutors, in addition to allowing self pacing and continuous monitoring, take account of individual differences in background, capabilities and needs. A student can ask a tutor for better explanations and elaborations. A tutor may notice that some students are having trouble with certain aspects of the problem and that more explanation and problems to practice are required. Thus tutors are recommended to students who need special attention.

CAI does not provide this dimension of tutoring. If the full benefits of computer technology in learning are to be realized, it is important to extend this student-computer interaction to cover tutoring. For the individual attention that computers offer to become really effective, they must assume the role of a tutor who observes student behaviour, finds students' mistakes, misunderstandings and lack of knowledge, and conveys appropriate information at the appropriate time using an appropriate explanation.

The emerging area of Expert Systems, also referred to as Knowledge Based Systems, provides a technology to capture expertise associated with outstanding human tutors to build a Computer Based Tutor. Several examples of such tutors already exist (Joobbani 1984), even though not all issues of CBT such as student modeling, and dialogue handling have yet been solved. One might very well expect that in the next two to three years there will be good authoring systems for CBT. It is interesting that some education software based on the approach of Expert Systems are already being marketed. Knowledge Based Systems, an important aspect of the fifth generation project, will undoubtedly be the way future education software development will go.

At present an inference engine, based on IF-THEN rules, can be used to get teachers to build CBT (Mahabala, 1985). These inference engines can be run on any computer currently being used in schools. However, the number of rules that can be included is somewhat limited due to memory capacity. However, this is still adequate to teach, for instance, qualitative analysis in chemistry. One can very well expect that classroom computers in the next few years will be sufficiently powerful (both in memory, and speed) to run good practical CBT.

Since Expert Systems allow the expert unskilled in programming to design CBT, and since the basic architecture of an expert system allows ready updating of information, it is necessary to expose teachers to this new approach to software so that all good teachers in a teaching system become creators of worthwhile CBT. Expert Systems will provide the new generation of authoring languages.

Computer languages

It is difficult to develop a program in binary form (0's and 1's) which is the language computers understand. It is possible for users to specify their computing requirements using a language tailored to their area. For example, FORTRAN allows one to use formulae very like English and suited to scientific applications, while COBOL is a commercially oriented language. BASIC is a computer language available on most microcomputers. Such user-oriented, high-level languages give a measure of machine independence (or portability) in that one can run the same program on different hardware.

There are a large number of languages and the choice of which language to use for a particular task needs considerable thought. Compilers (special software) translate high-level language text of a program into its binary equivalent. Compilers also point out errors in syntax (spelling and grammar) of the input program text (Source).

Courseware

Courseware (sometimes also called lessonware) refers to a curriculum package comprising a computer program (software) and accompanying learning materials. These learning materials may be student worksheets, manuals, or audio-visual materials.

Custom-Network (see also Network)

There are several techniques (protocols) for organizing digital communication between computers in a network. Also it is possible to have a network used exclusively by a group of users (such as a company). Such dedicated, non-standard networks are referred to as custom-networks.

Data Base

A data base is a large collection of data which a user is often interested in referring to. It is now possible to have packages to organize such data bases and search them for any desired requirement (query).

Disk

See Disk Drive

Disk Drive

A very low cost but low capacity version of a disk drive is a floppy disk drive. It is referred to by that name because the recording surface which can be removed is flexible and looks like a gramaphone record. It is either called a diskette or floppy disk. Here again technology has decreased the size of disks while still increasing memory capacity.

Previously 8 inch disks were most common; today 5¼ inch disks are most widely used. However, a smaller version still, with a diameter of 3 inches, is becoming popular not only because it is easy to transport and is rigid, but it also has a built-in dust cover. It is expected that 3-inch floppy disks will become standard for personal computers.

Diskette

See Disk Drive.

Dumb terminal

A dumb terminal is the name sometimes given to a user terminal which only facilitates input and output without possessing independent data processing capacity. With the availability of low cost microprocessors, intelligent terminals are being built which do some work such as checking syntax locally without having to load the central processor to which it is connected.

Ergonomics

The term ergonomics derives from the Greek word for "work", ergon, and nomos for "laws of", and it is used to refer to the interface of humans and tools or machines. The term is thus used to refer to the interaction of people and computers. The repetitive tasks involved in much keyboard entry have given rise to repetitive strain injury (RSI), sometimes called tenosynovitis or overuse injury. These aspects of the interaction of users and computers are part of the study of ergonomics or human factors engineering.

Expert System (see also CBT)

Those working on the development of artificial intelligence have been suggesting for quite some time that computer programs cannot produce intelligent behaviour unless one can incorporate into them knowledge that we normally associate with outstanding human experts. Many demonstrations have been given of such knowledge based systems. Such systems in addition to generating answers to queries can also offer explanations for decisions arrived at. They are so structured that one can easily modify the knowledge content.

Since human experts are the creators of knowledge based systems (also referred to as expert systems) one develops a general purpose 'reasoning' module, referred to as an 'Inference Engine'. Experts can build up specific knowledge relevant to their expertise in a very nearly natural language format and thus need not be programmers. One currently widely used method for incorporating knowledge is through use of IF-THEN rules, where a piece of knowledge is expressed in terms of recognizing a context (IF portion) and performing an appropriate action or drawing a conclusion (THEN part).

Already inference engines are available on microcomputers which enable one to generate an expert system in various areas such as computer based design, diagnosis, or teaching science. One of the important aims of the fifth generation project is to develop technology for building complex Knowledge Based Systems.

Fifth Generation Computers

Japan initiated a very ambitious project to develop technology for a new generation of computers (Fifth generation) not so much based on advances in hardware technology but on artificial intelligence-based applications. It is proposed that computers deal with knowledge, and a new discipline called knowledge engineering is emerging.

One of the outcomes of the project will be tools to build sophisticated expert systems. The project will also result in research and development on new computer architectures, data base organizations, intelligent user interfaces and Logic based programming languages.

The Japanese project has triggered similar efforts in other countries. One can expect as an outcome of the project, processes which execute close to one thousand million instructions per second. The aim is for man, the reasoning animal, to build a reasoning machine.

Graphics Terminal

A display unit which can display curves or any complicated design either in black and white or in colour, is a graphics terminal. The display is achieved by dividing the display area into a matrix of points called pixels (picture elements). Normally there are approximately 500 x 500 points (low resolution) although one can also have a high resolution plot using 1000 x 1000 pixels. Graphics terminals are used for Computer Aided Design. One can attach a hand movable small block called a Mouse which allows one to move a cursor on the screen. With the Mouse one can point at a location on a screen or draws patterns. Recently the mouse has become popular with personal computers.

Hardware

Hardware refers to computer equipment, as distinct from the programs that make the computer run. Thus hardware includes the computer, monitor, keyboard and peripherals such as tape and disk drives, printers and plotters.

Integrated Circuit (IC)

An integrated circuit is a combination of circuits packed very densely on a chip. See also VLSI.

Inference Engine

See Expert System.

Interface

A process of communication between two unlike units such as man and machine (called user interface) or central processor and peripherals is referred to as an interface. If an interface is standardized, peripherals can be supplied by different manufacturers. A user interface consists of appropriate procedures to operate and work with a system.

LAN (Local Area Network)

See Network

Laser Printer

It is possible to use a laser beam to draw a pattern of electrical charge on a drum and use it to print a corresponding image on paper by a technique similar to xeroxing. Such laser printers have recently become relatively cheap and may soon be standard on personal computers. Since a laser printer draws a pattern using a very fine beam, it can be used to draw text as well as any complicated graphical design, and thus can be used as a Printer-Plotter.

Local Script Adaptation (see also Graphics Terminal)

One can use a display unit in the printer-plotter mode to plot any curve. By defining a set of primitive shapes, one can display text in a output by making each character (or font) a juxtaposition of some primitive shapes. Since most of the terminals use a microprocessor one can convert the keyboard to reflect the typewriter in that language.

Logo

Logo is a programming package to convert the screen to a square of drawing paper and give the user the ability to draw patterns on it. A child can create complex patterns by giving a sequence of simple commands such as move left, move right, forward, backward, and so on. One can create repetitive patterns very easily.

Menu

Instead of requiring users to type long commands (even single words) one can display the set of permissible commands on the screen, either at the bottom or the side, so that the user can point to one of them by moving the cursor. The choices may also be numbered and users need type in only the number of the command requested. Obviously such a system is very convenient for lay-users and makes the user interface more friendly.

Microcomputer (micro)

A computer built around a microprocessor is a microcomputer, or micro.

Microprocessors

The basic information handled by a digital computer is in binary (O's and 1's). One binary unit is referred to as bit. Since a bit is rather small, groups of bits are used as a basic unit of information. The number in the group, also referred to as word, can vary from 8 to 48, in steps of 8. Obviously, the larger the word size, the faster one can one get a piece of computation done. Initially, because of limitations due to the complexity of electronics, word size was limited to 8 bits. Currently 16-bit word size is becoming popular since it is more powerful and costs about the same as 8-bit.

Monitor

A monitor is simply a modified television set used for displaying output from a computer. Like television sets, monitors can be black/white or colour. A monitor, coupled to a keyboard, becomes a user terminal.

Mouse

See Graphics Terminal.

Multiple-window

Normally information is displayed on a monitor treating the entire screen as one page. If one wants to display some other information (say a graph), one has to wipe-out the screen and use it. However users often wish to work with different information simultaneously. This is done by dividing the screen into several windows, each assigned to one type of information. It is likely that this versatile use of a screen will become standard in the course of time.

Network

Computers are able to communicate with each other by using standard communication techniques. The distance between computers is not really material and one can use either dedicated or public communication networks. Thus networks allow a user at one location to access a computer at another. Speed of communication is dependent on the media used for interconnecting.

Networks allow computing resources such as processors, peripherals and data bases to be shared. A network located in a small area (say, a building or a small campus) can provide very high speed communication using cables or optical fiber. Such small area networks are called local area networks (LAN). One can have a LAN even inside a room connecting several micros, terminals and minis.

Operating system

An operating system is a sophisticated program which helps the user to control the computer and all input/output facilities.

Package

A package is a specialized program designed to make it convenient to perform certain tasks - say, editing texts, handling a collection of data (data base), financial tasks, and so on. Users need not know programming but can use the package (with some built-in flexibility) to get jobs done quickly. The choice of a microcomputer by an individual depends a great deal on the availability of packages for doing tasks that he/she wants to do. Some companies deal only in developing and marketing specialized packages.

Peripheral

A computer needs to send (Output) and receive (Input) information from outside. Units performing these Input/Output functions are referred to as peripherals. Printers and Disk drives are examples of peripherals.

Printer-Plotter

Normally printers are used for printing text (similar to a typewriter). If, however, the print mechanism is based on a row of wires, each capable of printing one point, one can use such a printer to print curves. Such a versatile print unit is referred to as printer-plotter.

Program

A program is a set of ordered instructions in a computer language to control or direct computers to perform certain information processing or input/output tasks (see Software). To 'program' means to the write such instructions. A programmer is one who writes software; that is instructions in a computer language.

Programmed Instruction (also called Programmed Learning)

Programmed instruction refers to a form of learning, made popular by teaching machines and programmed learning textbooks, in which learners are presented with a frame, containing information and usually a question. On the basis of the learner's response, he/she is branched to another frame. Programmed instruction is commonly used to present drill and practice and tutorial activities (see also CAI).

Read Only

See Video Disk.

Repetitive Strain Injury (RSI)

See Ergonomics

Response time

This is the time lapse from the moment an instruction is given to the computer until the result or response is returned. When users sit in front of a terminal, they usually expect to get a response from the computer within a short period. If the response time is long, users may wonder whether anything is wrong. In order to produce acceptable response times, one may have to use a more powerful processor to execute the program faster. Response time not only depends on the speed of the CPU but also on the efficiency of the program and the peripherals used.

Robot

A robot is commonly thought of as a mechanical human-like unit with all senses and mobility. But a robot for a computer engineer is an assemblage of activators which convert electrical signals to mechanical movements. Such robots are a form of highly automated mechanisms for doing specialized tasks such as painting, sorting objects, carrying heavy objects in a space littered with obstacles, and so on.

Semiconductor Memory (see also VLSI)

Digital computers need memory to store data and programs. Such memories were in the early days based on magnetic core technology. However, with the advent of VLSI, one can fabricate large yet fast memories using semiconductor technology - memory on a chip.

Simulation

Simulations involve using the computer to model real phenomena or events. Simulation programs have been produced, for example, to model nuclear power plants, the energy loss in buildings, or particular ecosystems.

Software - broadcast

One can send by means of radio or television signals a sequence of bits which can be treated as a digital stream of coded information. The transmitter can broadcast the text of several programs on a round-robin basis so that a microcomputer equipped with an appropriate receiver can capture and load into its memory any particular program the user desires, thereby obviating the need for auxiliary storage on inexpensive personal computers.

Speech Synthesizer

Computers can produce as output, time-varying electrical signals which can be used to generate an acoustic signal using a speaker. By controlling the wave shape, it is possible to produce any tone or speech. A special chip can also be produced which generates a particular phoneme indicated by a code sent from the CPU. One can generate any speech coded as a sequences of phoneme codes. The speech, however, tends to sound 'metallic'. Sophisticated speech synthesizers can capture the quality of speech of particular speakers.

Spreadsheet

A spreadsheet is a package which enables a user to think in terms of a tabular worksheet divided into many columns and rows. With the computer, users can create tables with text or numbers and automatically compute fairly complex entries based on other entries. For example, with the computer, one can automatically calculate the cost of an item (given quantity and rate) and the total of a bill. Increasingly, accounting departments are using spreadsheets for their day-to-day work.

Video Disk

Laser technology has made it possible to put a huge amount of memory (trillion bits) on a disk surface. This This has lead to recording an entire movie on a disk. The same device can also be used to store digital information - thereby allowing one to provide extremely large auxiliary storage at very low cost. However, at the present time, it is cheap only for reading pre-recorded information (Read only). The Write Unit is still very expensive. Thus the video disk is used primarily as a repository of large data bases such as handbooks and encyclopaedias.

Videotex

Videotex is a generic term referring to a communications system comprising a central computer for storing information, the telephone network to distribute the information, and a keypad control often used with a television set to display the information. The system allows two-way transmission of information.

Some public videotex services are Prestel (UK), Captain (Japan) and Viatel (Australia).

VLSI (Very Large Scale Integrated Circuit)

Some time ago it was demonstrated that one can not only fabricate electronic components such as transistors, resistors and capacitors on a silicon chip, but also inter-connect them leading to what is referred to as integrated circuits. As component dimensions decreased, one could put more and more components on a chip leading to increasing levels of integration. The complete electronics of a processor could be put on a chip and thus was born the microprocessor chip. However, the ability to add more components has kept increasing. More than 100,000 components can now be placed on a chip, leading to far more complex computers on a chip.

This component density also permitted fabricating large memory capacities on a chip. Currently it is possible to put one million bits of memory on a chip. The general area of building high density digital chips is referred to as VLSI fabrication. One can today get custom-made VLSI chips in a matter of weeks and, that too, in a cost effective manner.

Winchester

The central processing unit (CPU) keeps information, which it is currently not working on, in auxiliary storage which is normally a magnetic medium. One such auxiliary storage is a disk unit where information is stored on circular rotating surfaces and I/O is performed by a read/write head which moves back and forth radially. In one type of disk unit, referred to as exchangeable disk drive, one can remove the medium and replace it with another, thereby being able to load or unload information from a system. The heads, however, remained on the drive. It was found that, if one could build an integrated sealed unit with both recording surfaces and read/write heads, one could get large capacities at very low cost. Such an integrated disk drive is called a Winchester drive.

Word Processor

A word processor is a package which allows a user to create text and format it the way a printer does. Some word processors automatically hyphenate to preserve constant column width, paginate, indent, and so on. Some even check spelling against a dictionary. Word processing is one of the most frequent and popular uses of personal computers.

LIST OF SELECTED APEID PUBLICATIONS RELATING TO COMPUTERS IN EDUCATION

Computers in education; final report of the Third Asian Seminar on Educational Technology. 1984 (obtainable from the Japanese National Commission for Unesco, Ministry of Education, Science and Culture, 3-2-2 Kasumigaseki, Chiyoda-ku, Tokyo, Japan).

Computers in education – an outline of country experiences. 1985.

Computers in education; Inventory of Training Institutions, Publications, Societies in Asia and the Pacific (Draft). 1985.

The Asia and Pacific Programme of Educational Innovation for Development (APEID) has as its primary goal to contribute to the building of national capabilities for undertaking educational innovations linked to the problems of national development, thereby improving the quality of life of the people in the Member States.

All projects and activities within the framework of APEID are designed, developed and implemented co-operatively by the participating Member States through over one hundred national centres which they have associated for this purpose with APEID.

The 24 Member States participating in APEID are Afghanistan, Australia, Bangladesh, China, Fiji, India, Indonesia, Iran, Japan, Lao People's Democratic Republic, Malaysia, Maldives, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Samoa, Socialist Republic of Viet Nam, Sri Lanka, Thailand, Tonga and Turkey.

Each country has set up a National Development Group (NDG) to identify and support educational innovations for development within the country and facilitate exchange between countries.

The Asian Centre of Educational Innovation for Development (ACEID), an integral part of the Unesco Regional Office for Education in Asia and the Pacific in Bangkok, co-ordinates the activities under APEID and assists the Associated Centres (AC) in carrying them out.

The programme areas under which the APEID activities are organized during the third cycle (1982-1986) are:

1. Universalization of education: access to education at first level by both formal and non-formal means;
2. Education for promotion of scientific and technological; competence and creativity;
3. Education and work;
4. Education and rural development;
5. Educational technology with stress on mass media and low-cost instructional materials;
6. Professional support services and training of educational personnel;
7. Co-operative studies and innovative projects of research and research-based experimentation related to educational development.